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(NASA-CR-152516) INVESTIGATION OF THE EFFECT OF ATMOSPHERIC DUST ON THE DETERMINATION OF TOTAL OZONE FROM THE EARTH'S ULTRAVIOLET REFLECTIVITY MEASUREMENTS, 1 (IBM Federal Systems Div.)

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INVESTIGATION OF THE EFFECT OF ATMOSPHERIC DUST ON THE DETERMINATION OF TOTAL OZONE FROM THE EARTH'S ULTRAVIOLET REFLECTIVITY MEASUREMENTS;

TECHNICAL REPORT: I

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Abstract

In this first technical report for the investigation of the effect of atmospheric dust on the estimation of total ozone from the earth's ultraviolet reflectivity measurements, we will describe two computer algorithms developed for this investigation. These algorithms can be used for computing the azimuth-independent component of the intensity of the monochromatic radiation emerging at the top a pseudo-spherical (see ¶4 of §I) atmosphere with arbitrary vertical distribution of ozone, and with any arbitrary height-distribution of up to two different kinds of aerosol. This atmospheric model is assumed to rest on a surface obeying Lambert's law of reflection.

I. INTRODUCTION

Ozone is perhaps the single most critical minor stratospheric constituent because its vertical distribution directly affects the deposition of energy in the stratosphere, while its total amount determines the ultraviolet radiation reaching the biosphere. Within the past decade, under the concern of increasing pollutant concentrations due to accelerated industrial and technological development, the stability of the stratospheric ozone layer has been questioned repeatedly. Because of this, considerable attention is being given currently to the problem of reliable and continuous measurement of atmospheric ozone on a global scale.

One of the techniques well suited for this purpose is a thorough analysis of the measurements of the earth's ultraviolet reflectivity. An accurate monitoring of this quantity on a global scale has been underway for the last six years, by Dr. Heath and his associates at NASA with the help of the Backscatter Ultraviolet double monochromator (BUV) aboard the NIMBUS-IV satellite. A more sophisticated version of this BUV experiment has been also accepted for the NIMBUS-G satellite under the leadership of Dr. D. F. Heath. This forthcoming experiment referred to as SBUV/TOMS (Solar and Backscatter Ultraviolet/Total Ozone Mapping System) is expected to be operational sometime during the calendar-year period 1977-1978.

The foundation of the analytic procedure currently used by the BUV team for estimating total ozone in a unit column from the reflectivity measurements of the earth-atmosphere system underneath, is a set of computed quantities [Mateer, Heath, and Krueger, 1971]. This set of quantities is computed after taking into account all orders of scattering, and following a modification of the procedure discussed by Dave [1964]. These computations are performed for nonhomogeneous pseudo-spherical models of the terrestrial atmosphere with different distributions of ozone, but without any aerosols or water-droplets. In this current BUV analytic procedure, contributions to the outgoing radiation due to scattering and/or absorption by aerosol are only approximately accounted for through the concept of the effective surface albedo which may or may not be equal to the reflectivity of the real, underlying surface. Accuracy and the confidence level of this current BUV analytic procedure can be considerably enhanced by using simulated measurements of the reflectivity of the earth-atmosphere system (with different compositions) in the current ozone-estimation program, and comparing the estimated total ozone and effective surface albedo with the actual input parameters. Such a numerical experiment requires computation of the backscattered radiation for a multitude of cases arrived at after combining various input parameters such as wavelength, solar zenith angle, ground reflectivity, ozone amount, and composition, size-distribution as well as height-distribution characteristics of aerosols.

The purpose of this first technical report is to describe a set of computer algorithms (FORTRAN IV language) specially developed for evaluating the azimuth-independent component of the intensity of scattered radiation emerging at the top of a pseudo-spherical atmospheric model with an arbitrary vertical distribution of ozone, and with arbitrary height-distributions of up to two different kinds of aerosols. The model is assumed to rest on a Lambert ground of reflectivity R. By pseudo-spherical, we mean that the sphericity of the atmosphere is only partly accounted for; viz., by computing attenuation suffered by the incoming solar radiation for the actual spherical case [see Eqs. (21), (22)] and by correcting the nadir angle of observation for the satellite's altitude above the underlying ground.

Computer requirements and the basic information needed for running these algorithms on an IBM 370 computer under VM-CMS are given in the §II of this report. In §III, we have described, in some detail, the method of the direct numerical solution of the Spherical Harmonics Approximation to the radiative transfer equation which is used by us for computing the emergent radiation after including all orders of scattering within the atmospheric model. Further information of help in understanding the mechanics of the actual computational procedures, is given in §IV. Listing of the actual FORTRAN statements, as well as input for, and output from a test run are given in §VII, VIII, and IX, respectively.

In a second Technical Report with the same title as this one, we propose to describe the results of a critical analysis of the ozone-estimation procedure currently being used by the BUV team. This analysis will be performed by making use of simulated measurements at five wavelengths (viz., 0.3125, 0.3175, 0.3312, 0.3398, and 0.3800 μm), and along the local nadir direction, for atmospheric models without any aerosols or water droplets. The recommendations resulting from this analysis will be used to develop a new procedure for the analysis of the simulated measurements along the local nadir direction for the SBUV/TOMS configuration where an additional measurement at 0.3600 μm will also be available.

In Technical Report III, we propose to investigate the effect of changes in atmospheric aerosol characteristics on the estimated total ozone, and on the estimated effective surface albedo, for both the BUV (viz., five wavelength) and the SBUV/TOMS (viz., six wavelength) configurations. This effect will be investigated for both configurations by making use of simulated measurements along the local nadir direction obtained with the help of algorithms described in the following sections.

II. OPERATING INSTRUCTIONS

Computations of the azimuth-independent component of intensity of the scattered radiation emerging at the top of a pseudo-spherical atmosphere with any arbitrary vertical distribution of ozone and/or aerosols by making use of the procedure discussed in §III and IV, require use of two algorithms, viz., SITAA, and SITBB. The first program (SITAA) is used for generating a dataset which is repeatedly used by the second program (SITBB). As such, the program SITAA has to be executed only once. These programs written in the FORTRAN IV language were developed, debugged, tested, and executed via an IBM 2741 Communication Terminal attached to an IBM 370/145 computer running under VM-CMS, and using the FORTRAN H extended, optimizer level 2, compiler. A 3-megabyte virtual machine with an attached 3330 disk space of 40 cylinders was used for this purpose.

2.1 <u>File Definition Statements</u>: A total of seven datafiles with the corresponding file definition statements listed below, are required during execution of the program SITBB for a given atmospheric model. They are used in the direct-access mode.

```
FI 11 DISK FILE FT11F001 A4 (XTENT 101 RECFM F LRECL 10000 BLKSIZE 10000
FI 12 DISK FILE FT12F001 A4 (XTENT 101 RECFM F LRECL 10000 BLKSIZE 10000
FI 13 DISK FILE FT13F001 A4 (XTENT 101 RECFM F LRECL 2200 BLKSIZE 2200
FI 14 DISK FILE FT14F001 A4 (XTENT 101 RECFM F LRECL 2200 BLKSIZE 2200
FI 15 DISK FILE FT15F001 A4 (XTENT 101 RECFM F LRECL 2004 BLKSIZE 2004
FI 16 DISK FILE FT16F001 A4 (XTENT 200 RECFM F LRECL 8720 BLKSIZE 8720
FI 17 DISK FILE FT17F001 A4 (XTENT 128 RECFM F LRECL 20000 BLKSIZE 20000
```

All datafiles are created under the A4 mode, and using a fixed format (RECFM F). The file number 11 contains 101 records (XTENT 101) of 10000 byte length each. For the simulated access methods under CMS (filemode A4), this file occupies a total of 1263 blocks of 800 byte length each. Similarly the files 12 through 17 occupy 1263, 278, 278, 254, 2180, and 3200 blocks, respectively.

These file definition statements must be executed before asking for the running of the main program.

The quantities stored in these datafiles will be described at the appropriate time in §IV.

2.2 Program SITAA: This program is used to compute, and to store on the disk as DISK FILE FT15F001, values of the integral

$$\int_0^1 \exp(-\tau/\mu)\, P_\ell(\mu)\, d\mu$$

for values of the parameters τ and ℓ given by $\tau = 0.00\ (0.01)\ 5.00$, and $\ell = 0\ (1)\ 100$, respectively. Values of this integral for all 501 values of the parameter τ but for a given value of the subscript ℓ, are stored as the record no. $(\ell + 1)$ in the datafile no. 15. This integral appears in Eq. (20).

Input to this program consists of the values of the zeros of $P_\ell(\mu)$ [values of μ (to 7 places after the decimal point) at which $P_\ell(\mu)$ is closest to zero for the given value of ℓ] arranged in increasing order of μ for a given ℓ, and then in the increasing order of the subscript ℓ (see §VII). The format for punching this information on cards is 5F10.7, 16X, I4.

Values of the above-mentioned integral are also obtained as an output in the printed form if, and only if, computations are completed for all desired values of the subscript ℓ.

2.3 Input for SITBB: Beside the dataset on the disk file no. 15 described in the preceding section, there are four additional sets of input to this program. The first set is related to input of the following parameters:

Parameter Name	Punched Card Format
NMOD, NBLYR	2I10
I, GTH(I), PRTH(I), OZOTH(I), STDUST(I), and TPDUST(I)	I5, 0P2F10.2, 0PF10.5, 1P2E11.2
TEMA, TEMB	2F10.5

The parameter NMOD represents the atmospheric model number. Each atmospheric model for which computations are to be performed should be assigned a unique number between 1 and 200. This is because all scattered-radiation information for this model required for further investigation, is stored as record no. NMOD in the datafile no. 16.

The second parameter NBLYR represents the number of basic layers into which a given atmospheric model is divided. This parameter should be greater than zero, and less than or equal to 32.

The third input parameter I represents the serial number of a basic layer in the model, with $I = 1$ corresponding to the topmost layer. The input parameters GTH(I), PRTH(I), OZOTH(I), STDUST(I), and TPDUST(I) represent geometric thickness (km), pressure thickness (mb), ozone thickness (atm-cm), number of particles (in a one sq. cm. column of a layer) for a kind of aerosol to be referred to as the stratospheric aerosol, and number of particles for another kind of aerosol to be referred to as the tropospheric aerosol in the I-th layer, respectively. The last two input parameters of this first set of input are the temporary constants TEMA and TEMB. They act as scalar multipliers to the input values of STDUST(I) and TPDUST(I), respectively.

The second set of input consists of a single card punched with the format I5, 3F10.4. It contains the quantities ILDA (serial number of the wavelength), ALDA [wavelength of the monochromatic radiation for which computations are to be performed (in μm)], TAUBSR [Rayleigh scattering optical thickness of the standard terrestrial atmosphere at sea-level for the wavelength ALDA (λ)], and OZABS (absorption coefficient of one atm-cm of ozone to the base e).

If there are any particles of the stratospheric aerosols, the program calls for a third set of input consisting of the following quantities:

Quantity	Format
BLDA, TITB(5), TITB(6), NMXST, BSCAST, BABSST, TITB(9), TITB(10), and TITB(11)	OP3F10.5, I5, 1P2E15.5, 3A4
COFAS(L) five values per card, and LM	1P5E13.5, I5

The quantity BLDA must be equal to ALDA within ±0.001, otherwise the program will be terminated with an appropriate message. The TITB vector represents the quantities to be used for creating a composite title for the model. The quantities TITB(5) and TITB(6) represent the real and the imaginary part of the refractive index of the stratospheric aerosol material, respectively. The normalized scattering phase function of a unit volume of the stratospheric aerosol [size distribution function stored in locations TITB(9), TITB(10) and TITB(11), and the refractive index ($m = n_1 - i\, n_2$) of its material stored in locations TITB(5) and TITB(6)] at the wavelength BLDA, is represented by a Legendre series with NMXST terms. The volume scattering and volume absorption coefficient per average particle of this aerosol distribution are given by BSCAST and BABSST, respectively. The coefficients of the above-mentioned Legendre series are represented by COFAS. The parameter LM representing the serial number of the very first coefficient punched on a COFAS card, is used to see if all COFAS cards are arranged in proper order. If not, the program is terminated with an appropriate message.

If there are any particles of the tropospheric aerosols, the program also calls for a fourth set of input consisting of the quantities BLDA, TITB(7), TITB(8), NMXTP, BSCATP, BABSTP, TITB(12), TITB(13), TITB(14), COFAT, and LM. The definition of these quantities can be obtained by replacing the word "stratospheric" in the preceding paragraph, with the word "tropospheric."

The third and fourth input datasets can be generated by using the program developed by the author under another NASA contract [Dave, 1972].

As mentioned earlier, the proposed ozone-estimation program for the NIMBUS G satellite calls for measurements of the back-scattered radiation at six different wavelengths, viz., 0.3125, 0.3175, 0.3312, 0.3398, 0.3600, and 0.3800 μm. Thus, for creation of the entire record no. NMOD on the datafile no. 16, it is necessary to follow input sets 2, 3, and 4, described above with corresponding sets for the remaining five wavelengths. To avoid any confusion, it is advisable to arrange all wavelengths in their increasing order, and refer to the 0.3125 μm wavelength with ILDA = 1, and the 0.3800 μm wavelength with ILDA = 6.

It should be pointed out that for each of these six wavelengths, computations are carried out for a total of eleven different cases of illumination; ten unidirectional ones from above (i.e., ten different values of the solar zenith angle θ_0), and the eleventh case of the isotropic illumination from below. These ten values of θ_0, viz., 0°, 45°, 60°, 70°, 75.6°, 79.6°, 82.5°, 84.7°, 86.7°, and 90° are given by a data statement in the subroutine LEGFUN (§4.3) called by SITBB. Furthermore, for each of these eleven cases of illumination, azimuth-independent component of the intensity of the scattered radiation emergent at the top is calculated for 18 different values of the nadir angle θ. The scanning mechanism of the TOMS instrument on the NIMBUS-G satellite (a circular orbit with a nominal altitude of 955 km above the mean sea-level) is planned to step through eighteen 3° steps from the nadir to horizon, i.e., $\theta' = 0°\ (3°)\ 51°$. A value of θ corresponding to a given value of θ' is also computed within the LEGFUN subroutine by using the formula

$$\sin\theta = (7326/6371)\sin\theta' , \tag{1}$$

where the radius of the earth is taken to be equal to 6371 km.

2.4 Output from SITBB: For an atmospheric model containing both stratospheric and tropospheric aerosols, the printed output consists of the following seven sets for each of the six wavelengths. In addition, the record number NMOD in the datafile no. 16 is also created.

The first set of output is essentially a reproduction of the input atmospheric parameters GTH(I), PRTH(I), etc. The input values of the Legendre coefficients for the stratospheric and tropospheric aerosols of a given refractive index, and for the wavelength under investigation, are reproduced in the second and the third sets, respectively. The fourth set of the output neatly summarizes all optical information about the atmospheric model for the wavelength currently under investigation.

The fifth set of output can be understood only after some knowledge of the mechanics of the method of direct numerical solution of the spherical harmonics approximation to the radiative transfer equation. The Legendre series representing the scattering phase function of molecules consists of the first three terms only, while those for the stratospheric and tropospheric aerosols consist of NMXST and NMXTP terms, respectively. A provision is made to accommodate values of NMXTP or NMXST as high as 300. Experience has shown that nothing of practical value is gained by computing higher-order scattering contribution with all non-vanishing terms of the Legendre series [Dave, 1975]. Hence, for values of NMXST and/or NMXTP > 40, the Legendre series is terminated when a preselected and pretested criterion is satisfied. In other words, higher-order scattering contribution (i.e., except for the first scattering of the direct beam illuminating the atmosphere from the outside) to the emergent radiation is represented by the P_L-th approximation where $(L+1) < NMXST$ and/or NMXTP. The first line of this fourth set gives the order of the P_L approximation used in the evaluation of the higher-order scattering contribution.

As mentioned in §2.3, the atmospheric model is divided into NBLYR number of basic layers. In order to maintain the accuracy in computation, all basic layers with optical thickness greater than 0.02 are divided into sublayers so that the optical thickness of no sublayer exceeds 0.02. A provision is made in the program to accommodate up to 300 sublayers. The program is terminated with an appropriate message if the number of sublayers required should exceed 300.

After dividing the basic layers into sublayers, positions of several sublevels are selected for performing stabilizing transformations on a matrix ($\underline{F}_j$) representing the optical characteristics of the model. A provision is again made to accommodate cases requiring such a stabilizing transformation of the $\underline{F}_j$ matrix at up to 100 points. The program is terminated if a particular case requires more than 100 conditioning points. If not, the second part of the fourth set of output contains information about the level number and optical depth of all sublevels at which such stabilizing transformations are to be performed. Such a sublevel is called a conditioning point.

Further information about this stabilizing transformation will be provided in §3.4. It is sufficient to state here that this $\underline{F}_j$ matrix is a rectangular matrix of the order $(L+1) \times (L+1)/2$, and that performance of a stabilizing transformation on it requires an inversion of its top-half. The following message is printed out after attempting to invert the top-half of $\underset{\sim}{F}_j$ at a given conditioning point: THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER N ITERATIONS FOR CONDITIONING POINT NUMBER J. If the attempt is successful, the quantity N in this message carries a positive value and computations proceed further. If the attempt is unsuccessful, the quantity N has a zero, or a negative value. In this latter case, the program is terminated. The criteria used for selecting the total number of conditioning points for a given run are based on extensive numerical investigations previously carried out by the author and his colleague [e.g., Dave and Canosa, 1974]. However, if the program should terminate with a negative value for the quantity N, it can be re-run by increasing the number of conditioning points (§3.4).

The last part of the fifth set of the output is a message stating that the linear system of equations (§3.3 and 3.4) has been solved successfully for a given illumination of the atmosphere from the outside.

The sixth set of the printed output is related to the directly transmitted and diffusely transmitted, as well as diffusely reflected fluxes passing through various basic levels of the model. Values of the net fluxes are also printed out. These quantities are for π units of energy passing through a unit area normal to the direction of incidence if the incident radiation is unidirectional (i.e., solar radiation at the top), and for π units of energy passing through a horizontal unit area at the bottom if the incident radiation is isotropically distributed. The value of the quantity SBAR representing the diffuse flux reflectivity of the model for the case of isotropic illumination from below, is also printed out at the bottom of this sixth set [see Eq. (2) below].

The azimuth-independent component of the intensity of the scattered radiation emerging at the top of the model is a function of the following six parameters: wavelength (λ), total ozone amount in the model (Ω), pressure at the base of the model (P), Lambert reflectivity of the ground (R), and the directional parameters θ_0 and θ. (It also depends upon various characteristics of aerosols present in the model, and also to some extent, on the vertical distribution of ozone.) Its value for a given value of R can be expressed as follows as the sum of two terms [see Eqs. (20), and (23), and also §3.5]:

$$I(\lambda, \Omega, P, R, \theta, \theta_0) = I(\lambda, \Omega, P, R=0, \theta, \theta_0) + \frac{T(\lambda, \Omega, P, \theta, \theta_0)\, R}{1 - R\,\bar{S}(\lambda, \Omega, P)} \tag{2}$$

No dependence on the azimuth angle appears because we are dealing only with the azimuth-independent component. The first term on the right hand side of Eq. (2) is the intensity of the emergent radiation in the absence of any ground reflection. The quantity $T(\lambda, \Omega, P, \theta, \theta_0)$ represents total (direct plus diffuse) transmission by the atmospheric model in the direction θ when the atmosphere is illuminated from below by the isotropic radiation. The quantity $\bar{S}(\lambda, \Omega, P)$ was described in the earlier paragraph. Further information about these quantities can be found in §3.1.

The last set of the printed output is a table containing values of $I(\lambda, \Omega, P, R=0, \theta, \theta_0)$ and $T(\lambda, \Omega, P, \theta, \theta_0)$ for 10 different values of θ_0, and 18 different values of θ given in §2.3. The value of the quantity $\bar{S}(\lambda, \Omega, P)$ is also repeated at the end of this output.

Summarized information about the model along with values of $I(\lambda, \Omega, P, R=0, \theta, \theta_0)$, $T(\lambda, \Omega, P, \theta, \theta_0)$, and $\bar{S}(\lambda, \Omega, P)$ for all six wavelengths, and various θ, θ_0 combinations wherever applicable, are stored as the record number NMOD in the file no. 16 for future use.

III. THEORY

3.1 Definitions: In this subsection, we will provide brief definitions of various quantities required in understanding the spherical harmonics approximation to the equation of radiative transfer for the azimuth-independent component of the scattered radiation in a plane-parallel atmosphere.

Parameter μ: The direction of propagation is denoted by the zenith angle ($\theta \equiv \cos^{-1}|\mu|$) which the direction makes with the local zenith. A negative (positive) sign before μ will imply the radiation traveling along the downward (upward) direction.

Normal optical thickness: For an atmospheric model with scattering by air molecules, absorption by ozone, and scattering as well as absorption by two different kinds of aerosols of interest to us, the optical depth τ of a level h km above the ground is given by

$$\tau = \tau^{(s,R)} + \tau^{(a)} + \tau^{(s,ST)} + \tau^{(a,ST)} + \tau^{(s,TP)} + \tau^{(a,TP)} . \qquad (3)$$

The first component, $\tau^{(s,R)}$, of τ is given by

$$\tau^{(s,R)} = \int_h^\infty k^{(s,R)} \rho(h)\, dh , \qquad (4)$$

where $k^{(s,R)}$ is the mass Rayleigh scattering coefficient of air at the wavelength λ under investigation, and $\rho(h)$ is the density of air at height h. To a very good first approximation, the value of the Rayleigh scattering optical thickness $\tau^{(s,R)}$ at any atmospheric level can be obtained from the value of $\tau_b^{(s,R)}$ (Rayleigh scattering optical thickness of the entire atmosphere), by making use of the following relationship:

$$\tau^{(s,R)}/\tau_b^{(s,R)} = p/p_b , \qquad (5)$$

where p and p_b are the atmospheric pressures at the level under consideration and at the bottom of the atmosphere, respectively. The second component, $\tau^{(a)}$, of the normal optical thickness due to absorption by ozone is given by

$$\tau^{(a)} = \alpha\, \Omega(h) , \qquad (6)$$

where α is the pressure and temperature independent absorption coefficient of ozone at the wavelength λ, and $\Omega(h)$ is the amount of ozone in atm-cm above the level h. The third and fourth components, $\tau^{(s,ST)}$ and $\tau^{(a,ST)}$, of τ are due to scattering and absorption by the stratospheric aerosol, respectively. Similarly, the last two components of τ are due to the presence of the tropospheric aerosol in the model. The optical thickness, $\tau^{(x,y)}$, due to the y type of aerosol and x type of the process is obtained from the following relationship:

$$\tau^{(x,y)} = N^{(y)}(h)\,\bar{\beta}^{(x,y)} \tag{7}$$

where $N^{(y)}(h)$ is the total number of <u>average</u> particles of the y-kind of aerosol in a column of 1-cm^2 cross-section above the level h km above the ground, and $\bar{\beta}^{(x,y)}$ is the x kind of volume cross-section for the y-kind of aerosol. Values of $\bar{\beta}^{(x,y)}$ for a spherical polydispersion made from a material of known refractive index $(m = n_1 - i\,n_2)$, and for a given wavelength can be computed by making use of the programs developed under another NASA contract by the author [Dave, 1972].

<u>Albedo of single scattering</u>: Also of interest are the albedos of single scattering of a unit volume due to molecules, and stratospheric as well as tropospheric aerosols. If $\Delta\tau$ is the incremental optical depth at the level τ, then these quantities are respectively given by

$$\left.\begin{aligned} \omega_R(\tau) &= \Delta\tau^{(s,R)}/\Delta\tau\,, \\ \omega_{ST}(\tau) &= \Delta\tau^{(s,ST)}/\Delta\tau\,, \\ \text{and}\quad \omega_{TP}(\tau) &= \Delta\tau^{(s,TP)}/\Delta\tau \end{aligned}\right\}. \tag{8}$$

The quantities $\Delta\tau^{(s,R)}$, $\Delta\tau^{(s,ST)}$, and $\Delta\tau^{(s,TP)}$ are incremental optical depths at the level τ due to molecules, stratospheric aerosols, and tropospheric aerosols, respectively.

Normalized scattering phase function: This quantity represents, on a relative scale, the fraction of incident energy scattered by a unit volume at a level τ in the direction μ, ϕ when that volume is illuminated from the direction μ', ϕ'. (ϕ or ϕ' represents the azimuth angle of the direction of propagation referred to an arbitrarily chosen meridian plane.) This quantity, $P(\tau; \mu, \phi; \mu', \phi')$, can be represented by a Fourier series whose argument is $(\phi' - \phi)$. Accordingly,

$$P(\tau; \mu, \phi, \mu', \phi') = \sum_{n=0}^{\infty} P^{(n)}(\tau; \mu, \mu') \cos n(\phi' - \phi) . \tag{9}$$

We will only consider the $P^{(0)}(\tau; \mu, \mu')$ coefficient of this series as our interest is restricted to the azimuth-independent component of the intensity of the scattered radiation. A value of $P^{(0)}(\tau; \mu, \mu')$ is given by

$$P^{(0)}(\tau; \mu, \mu') = \sum_{\ell=0}^{\infty} \Lambda_\ell(\tau)\, P_\ell(\mu)\, P_\ell(\mu') , \tag{10}$$

where $P_\ell(\mu)$ are the ordinary Legendre polynomials, and coefficients $\Lambda_\ell(\tau)$ are given by

$$\Lambda_\ell(\tau) = \omega_R(\tau)\, \Lambda_\ell^{(R)} + \omega_{ST}(\tau)\, \Lambda_\ell^{(ST)} + \omega_{TP}(\tau)\, \Lambda_\ell^{(TP)} . \tag{11}$$

Values of the normalized Legendre coefficients for Rayleigh scattering are as follows: $\Lambda_0^{(R)} = 1$, $\Lambda_1^{(R)} = 0$, $\Lambda_2^{(R)} = 0.5$, and for $\ell > 2$, $\Lambda_\ell^{(R)} \equiv 0$. The normalized Legendre coefficients $\Lambda_\ell^{(ST)}$ and $\Lambda_\ell^{(TP)}$ representing the normalized scattering phase function of a unit volume of the stratospheric and tropospheric aerosols, respectively, are functions of the wavelength under investigation, refractive index of the aerosol material, and size distribution of aerosol particles. Their values can be obtained by making use of the programs used for generation of the quantity $\overline{\beta}^{(x,y)}$ described in the preceding paragraph. It should be added that the Legendre coefficients $\Lambda_\ell^{(R)}$, $\Lambda_\ell^{(ST)}$ and $\Lambda_\ell^{(TP)}$ are so normalized that integration of their respective scattering phase functions over a solid angle of 4π, yields a value of 4π.

Intensity: The intensity of a beam of monochromatic radiation of wavelength λ is defined as the amount of energy per unit wavelength interval at λ flowing per unit time in a cone of unit solid angle with its axis coinciding with the direction of propagation of energy. Let $I(\tau; \mu, \phi; -\mu_0, \phi_0)$ be the intensity of the scattered radiation emerging at a level τ, in the direction μ, ϕ. [The parameters $(-\mu_0, \phi_0)$ represents the direction of incidence of the incoming solar radiation with $\mu_0 = \cos\theta_0$.] This intensity is also a function of several other parameters such as magnitude of the energy incident upon the atmosphere from outside, optical characteristics of the atmospheric model, and reflectivity of the surface underlying the atmosphere. This quantity $I(\tau; \mu, \phi; -\mu_0, \phi_0)$ can also be expressed in a Fourier series of the form given by Eq. (9). However, we are only interested in the azimuth-independent component of this series, viz., $I^{(0)}(\tau; \mu, -\mu_0)$ which we will, henceforth, refer to as $I(\tau; \mu, -\mu_0)$ for brevity.

For an atmospheric model resting on a perfectly absorbing surface and illuminated at the top by the direct solar radiation with the solar zenith angle θ_0, the quantity $I(\tau = 0; \mu, -\mu_0)$ corresponds to the first term on the right hand side of Eq. (2) provided λ, Ω, P, and other parameters of the model are understood to be the same for both.

We can also define the intensity $I(\tau = 0; \mu, \text{iso})$ representing the scattered radiation emerging at the top of the same atmospheric model when it is illuminated by an isotropically distributed radiation of unit strength from below. The second term $T(\lambda, \Omega, P, \theta, \theta_0)$ appearing in the second term on the right hand side of Eq. (2) can be obtained after multiplying the quantity $[I(\tau = 0; \mu, \text{iso}) + \exp(-\tau_b/\mu)]/\pi$ by the sum of the direct solar flux and diffuse sky flux emerging at the level τ_b for the appropriate value of θ_0.

Intensity moments: The ℓ-th Legendre moment of the intensity is defined as follows:

$$f_\ell(\tau; x) = \int_{-1}^{+1} I(\tau; \mu, x)\, P_\ell(\mu)\, d\mu \, , \qquad (12)$$

where $x = -\mu_0$ represents the case of unidirectional illumination from above, and $x = \text{iso}$ represents the case of isotropic illumination from below.

3.2 Spherical Harmonics Approximation: The method for deriving a spherical harmonics approximation to the equation of radiative transfer for the azimuth-independent component of the scattered radiation in a plane-parallel atmosphere is well known and is available in the open literature. We will therefore only enumerate its final form in this section. Readers interested in further details on this subject are referred to several recent publications on this subject [e.g., Dave and Canosa, 1974; Dave, 1974 and 1975]. The following is a concise form of the P_L-th Spherical Harmonics Approximation (the parameter L is allowed to have only odd values to keep intensity moments continuous across interfaces of different layers):

$$\underset{\sim}{A} \frac{d\, \underset{\sim}{f}(\tau; x)}{d\tau} + \underset{\sim}{C}(\tau)\, \underset{\sim}{f}(\tau; x) = \underset{\sim}{s}(\tau; x)\,, \tag{13}$$

where $\underset{\sim}{A}$ is a bidiagonal matrix given by

$$\underset{\sim}{A} = \begin{bmatrix} 0 & 1 & & & & & & \bigcirc & \\ 1/3 & 0 & 2/3 & & & & & & \\ & 2/5 & 0 & 3/5 & & & & & \\ & & \cdot & \cdot & \cdot & & & & \\ & & & \cdot & \cdot & \cdot & & & \\ & & & & \cdot & \cdot & \cdot & & \\ & \bigcirc & & & & \frac{L-1}{2L-1} & 0 & \frac{L}{2L-1} \\ & & & & & & \frac{L}{2L+1} & 0 \end{bmatrix}, \tag{14}$$

and $\underset{\sim}{C}(\tau)$ is a diagonal matrix given by

$$
\underset{\sim}{C}(\tau) = \begin{bmatrix} \sigma_1(\tau) & & & & & & & \\ & \sigma_2(\tau) & & & & & \bigcirc & \\ & & \sigma_3(\tau) & & & & & \\ & & & \cdot & & & & \\ & & & & \cdot & & & \\ & & & & & \cdot & & \\ & \bigcirc & & & & & \sigma_{L-1}(\tau) & \\ & & & & & & & \sigma_L(\tau) \end{bmatrix}, \tag{15}
$$

with its element $\sigma_\ell(\tau)$ given by

$$
\sigma_\ell(\tau) = \frac{\Lambda_\ell(\tau)}{2\ell + 1} - 1 . \tag{16}
$$

The column vectors $\underset{\sim}{f}(\tau; x)$ and $\underset{\sim}{s}(\tau; x)$ of length $(L+1)$ are given by

$$
\underset{\sim}{f}(\tau; x) = \begin{bmatrix} f_0(\tau; x) \\ f_1(\tau; x) \\ f_2(\tau; x) \\ \cdot \\ \cdot \\ \cdot \\ f_{L-1}(\tau; x) \\ f_L(\tau; x) \end{bmatrix}, \tag{17}
$$

and

$$\underset{\sim}{s}(\tau; x) = \begin{bmatrix} s_0(\tau; x) \\ s_1(\tau; x) \\ s_2(\tau; x) \\ \cdot \\ \cdot \\ \cdot \\ s_{L-1}(\tau; x) \\ s_L(\tau; x) \end{bmatrix}, \tag{18}$$

respectively.

The elements $f_\ell(\tau; x)$ of $\underset{\sim}{f}(\tau; x)$ are defined by Eq. (12). Values of $s_\ell(\tau; x)$ for $x = -\mu_0$ and $x = \text{iso}$ are given by the following equations:

$$s_\ell(\tau; -\mu_0) = \frac{-\Lambda_\ell(\tau)}{2(2\ell+1)} F\, e^{-\tau/\mu_0} P_\ell(-\mu_0) , \tag{19}$$

and

$$s_\ell(\tau; \text{iso}) = \frac{-I_g(-\mu_0)\,\Lambda_\ell(\tau)}{2\ell+1} \int_0^1 e^{-(\tau_b - \tau)/\mu_1} P_\ell(\mu_1)\, d\mu_1 . \tag{20}$$

The expression for $s_\ell(\tau; -\mu_0)$ is for the case of a plane-parallel atmosphere illuminated by a monochromatic, unidirectional solar radiation of net flux πF per unit area normal to the direction of its propagation represented by $-\mu_0, \phi_0$. (The quantity F will be taken to be unity during computations.) For a pseudo-spherical atmosphere, the term $\exp(-\tau/\mu_0)$ appearing on the right hand side of Eq. (19) should be replaced by the term $\text{atten}_j(-\mu_0)$. This new term represents the attenuation suffered by the incoming solar radiation arriving at the j-th level where the optical depth is τ, and makes an angle θ_0 with the local zenith at that point. It is given by

$$\text{atten}_j(-\mu_0) = \sum_{i=1}^{j} \Delta s_{i,j}(-\mu_0)\, \Delta\tau_i \,, \tag{21}$$

where $\Delta s_{i,j}(-\mu_0)$ represents the magnification of a one km vertical path in the i-th layer while reaching the j-th level. It is given by

$$\begin{aligned} \Delta s_{i,j}(-\mu_0) = {} & [h_{i-1} - h_i]^{-1} \\ & \times \Big\{ [(a+h_j)^2 \mu_0^2 + (h_{i-1} - h_j)(2a + h_{i-1} + h_j)]^{\frac{1}{2}} \\ & - [(a+h_j)^2 \mu_0^2 + (h_i - h_j)(2a + h_i + h_j)]^{\frac{1}{2}} \Big\} \,. \end{aligned} \tag{22}$$

Initial computations of $s_\ell(\tau; \text{iso})$ are carried out by taking a unit value for the quantity $I_g(-\mu_0)$ appearing on the right hand side of Eq. (20). Values of $s_\ell(\tau; \text{iso})$ so obtained would lead to computations of $I(\tau = 0; \mu, \text{iso})$ (see §3.1) when the procedure discussed in §3.4 is followed. These values of $[I(\tau = 0; \mu, \text{iso}) + \exp(-\tau_b/\mu)]$ can be then corrected to obtain the second term on the right hand side of Eq. (2) for each θ_0, by making use of a value of $I_g(-\mu_0)$ given by the following equation:

$$I_g(-\mu_0) = \frac{R[F\mu_0\, e^{-\tau_b/\mu_0} + 2|f_1(\tau_b; -\mu_0)|]}{1 - 2R|f_1(\tau_b; \text{iso})|} \,. \tag{23}$$

The quantity $2|f_1(\tau_b; \text{iso})|$ is the same as $\bar{S}(\lambda, \Omega, P)$ introduced in §2.4. The first and second terms inside the parenthesis in the numerator on the right hand side of Eq. (23) when multiplied by a factor of π, represent the direct solar flux and the diffuse sky radiation flux incident on the ground, respectively. Again, the factor $\exp(-\tau_b/\mu_0)$ appearing in Eq. (23) should be replaced by $\text{atten}_j(-\mu_0)$ for the value of the subscript j corresponding to the bottom of the atmosphere.

Finally, the boundary conditions of incidence of no scattered radiation from outside the atmosphere is given in terms of the Marshak's boundary condition matrix $\underset{\sim}{G}$ [a square matrix of the order $(L+1)/2$] by the following two equations:

$$\underset{\sim}{f}_{odd}(\tau = 0; x) = -\underset{\sim}{G}\,\underset{\sim}{f}_{even}(\tau = 0; x) , \tag{24}$$

and

$$\underset{\sim}{f}_{odd}(\tau = \tau_b; x) = \underset{\sim}{G}\,\underset{\sim}{f}_{even}(\tau = \tau_b; x) , \tag{25}$$

where

$$\underset{\sim}{f}_{odd}(\tau; x) = \begin{bmatrix} \underset{\sim}{f}_1(\tau; x) \\ \underset{\sim}{f}_3(\tau; x) \\ \cdot \\ \cdot \\ \cdot \\ f_L(\tau; x) \end{bmatrix} , \tag{26}$$

and

$$\underset{\sim}{f}_{even}(\tau; x) = \begin{bmatrix} f_0(\tau; x) \\ f_2(\tau; x) \\ \cdot \\ \cdot \\ \cdot \\ f_{L-1}(\tau; x) \end{bmatrix} . \tag{27}$$

Expressions for computing elements of the $\underset{\sim}{G}$ matrix can be found elsewhere [e.g., Dave, 1974].

In concluding this subsection, we explicitly mention that Eq. (13) consists of $L+1$ inhomogeneous ordinary differential equations. The general solution, therefore, requires $(L+1)$ arbitrary constants of integration. Equation (24) provides $(L+1)/2$ conditions for determining one-half of these $(L+1)$ arbitrary constants of integration, while Eq. (25) provides $(L+1)/2$ additional conditions for determining the remaining one-half of these $(L+1)$ arbitrary constants of integration.

3.3 Form for the Direct Numerical Solution: Equation (13) along with the boundary conditions given by Eqs. (24) and (25) can be reduced to the following block algebraic system after dividing the atmospheric model into several layers of constant optical properties, and integrating Eq. (13) between two optical levels τ_{j-1} and τ_j ($j = 1$ corresponding to the top of the atmosphere) with the trapezoidal rule of integration:

$$\underset{\sim}{D}_{11}\underset{\sim}{g}_1 + \underset{\sim}{D}_{12}\underset{\sim}{g}_2 = \underset{\sim}{w}_1 ,$$

$$\underset{\sim}{D}_{22}\underset{\sim}{g}_2 + \underset{\sim}{D}_{23}\underset{\sim}{g}_3 = \underset{\sim}{w}_2 ,$$

$$\cdot$$
$$\cdot$$
$$\cdot$$

$$\underset{\sim}{D}_{J-1,J-1}\underset{\sim}{g}_{J-1} + \underset{\sim}{D}_{J-1,J}\underset{\sim}{g}_J = \underset{\sim}{w}_{J-1} ,$$

$$\underset{\sim}{g}_1^b = -\underset{\sim}{G}\,\underset{\sim}{g}_1^t \quad \text{and} \quad \underset{\sim}{g}_J^b = \underset{\sim}{G}\,\underset{\sim}{g}_J^t . \tag{28}$$

The bottom-most level of the model is represented by the subscript J. The details for arriving at Eq. (28) starting with Eqs. (13), (24), and (25), can be found in a report by the author [Dave, 1974]. The $\underset{\sim}{D}_{j-1,j-1}$ and $\underset{\sim}{D}_{j-1,j}$ matrices [order $(L+1)$] are functions of the optical characteristics of the atmospheric models, while the $\underset{\sim}{g}_j$ and $\underset{\sim}{w}_j$ vectors are functions of τ_j and x where $x = -\mu_0$ or, iso. (For the sake of brevity, explicit referring to these parameters is not done in the following discussion.) Various quantities appearing in Eq. (28) are defined as follows:

$$\underset{\sim}{g}_j = \begin{bmatrix} \underset{\sim}{f}_{even}(\tau_j; x) \\ \underset{\sim}{f}_{odd}(\tau_j; x) \end{bmatrix} . \tag{29}$$

$$\underset{\sim}{w}_{j-1} = \frac{1}{2}\,\Delta\tau_{j-1}\left[\underset{\sim}{s}(\tau_{j-1}; x) + \underset{\sim}{s}(\tau_j; x)\right] , \tag{30}$$

with

$$\Delta\tau_j = \tau_j - \tau_{j-1} . \tag{31}$$

$$\underset{\sim}{D}_{j-1,j-1} = \text{Column}\left[-\underset{\sim}{A} + \frac{1}{2}\Delta\tau_{j-1}\,\underset{\sim}{C}(\tau_{j-1} + \frac{1}{2}\Delta\tau_{j-1})\right] , \tag{32}$$

and

$$\underset{\sim}{D}_{j-1,j} = \text{Column}[\underset{\sim}{A} + \frac{1}{2}\,\Delta\tau_{j-1}\,\underset{\sim}{C}(\tau_{j-1} + \frac{1}{2}\,\Delta\tau_{j-1})]\,, \tag{33}$$

where a column operator on a matrix denotes the rearrangement of its columns by parity. That is, the first half of the columns of the resulting matrix are the 1st, 3rd, 5th, $\cdots$, Lth columns of the matrix inside the parenthesis, and second half the 2nd, 4th, $\cdots$, (L+1)st columns.

Finally, the superscripts b and t on the $\underset{\sim}{g}_j$ vector in the last equation in the system (28) represent the bottom-half and top-half of the corresponding vector, respectively.

In order to obtain a direct numerical solution of the block algebraic system represented by Eq. (28), it is necessary to introduce the following sequence of rectangular matrices of order $(L+1) \times (L+1)/2$:

$$\left.\begin{aligned}
\underset{\sim}{F}_1 &= \begin{bmatrix} \underset{\sim}{I} \\ -\,\underset{\sim}{G} \end{bmatrix}, \\
\underset{\sim}{F}_2 &= \underset{\sim}{\pi}_1\,\underset{\sim}{F}_1\,, \\
\underset{\sim}{F}_3 &= \underset{\sim}{\pi}_2\,\underset{\sim}{\pi}_1\,\underset{\sim}{F}_1 = \underset{\sim}{\pi}_2\,\underset{\sim}{F}_2\,, \\
&\;\;\vdots \\
\underset{\sim}{F}_J &= \underset{\sim}{\pi}_{J-1}\,\underset{\sim}{\pi}_{J-2}\cdots\underset{\sim}{\pi}_1\,\underset{\sim}{F}_1 = \underset{\sim}{\pi}_{J-1}\,\underset{\sim}{F}_{J-1}
\end{aligned}\right\}, \tag{34}$$

where the square matrix $\underset{\sim}{\pi}_j$ of the order (L+1) is given by

$$\underset{\sim}{\Pi}_j = -\underset{\sim}{D}_{j,j+1}^{-1}\underset{\sim}{D}_{j,j}, \tag{35}$$

and $\underset{\sim}{I}$ is a unit matrix.

It is also necessary to introduce the following sequence of vectors $\underset{\sim}{a}_j$ of $(L+1)$ components:

$$\left.\begin{aligned}
\underset{\sim}{a}_1 &= \underset{\sim}{0},\\
\underset{\sim}{a}_2 &= \underset{\sim}{D}_{12}^{-1}\underset{\sim}{w}_1 + \underset{\sim}{\Pi}_1\underset{\sim}{a}_1,\\
\underset{\sim}{a}_3 &= \underset{\sim}{D}_{23}^{-1}\underset{\sim}{w}_2 + \underset{\sim}{\Pi}_2\underset{\sim}{a}_2,\\
&\;\;\vdots\\
\underset{\sim}{a}_J &= \underset{\sim}{D}_{J-1,J}^{-1}\underset{\sim}{w}_{J-1} + \underset{\sim}{\Pi}_{J-1}\underset{\sim}{a}_{J-1}
\end{aligned}\right\}. \tag{36}$$

Equation (28) can be then rewritten in the following concise form:

$$\underset{\sim}{g}_j = \underset{\sim}{F}_j\,\underset{\sim}{g}_1^t + \underset{\sim}{a}_j, \qquad j = 1, 2, \cdots, J. \tag{37}$$

After applying the lower-boundary conditions, the top and bottom half of $\underset{\sim}{g}_J$ of Eq. (37) can be related as follows:

$$\left(\underset{\sim}{F}_J^b - \underset{\sim}{G}\,\underset{\sim}{F}_J^t\right)\underset{\sim}{g}_1^t = \underset{\sim}{G}\,\underset{\sim}{a}_J^t - \underset{\sim}{a}_J^b. \tag{38}$$

Equation (38) now consists of $(L+1)/2$ unknowns, viz., the components of $\underset{\sim}{g}_1^t$ at $\tau = 0$ (i.e., $\tau = \tau_1$), and are functions of $x(= -\mu_0$ or, iso). The matrix $\underset{\sim}{F}_J^b - \underset{\sim}{G}\,\underset{\sim}{F}_J^t$ is dependent only upon the optical properties of the atmospheric model. The vector $\underset{\sim}{G}\,\underset{\sim}{a}_J^t - \underset{\sim}{a}_J^b$ depends upon properties of the model, as well as on the parameter $x(= -\mu_0$ or, iso). Having determined $\underset{\sim}{g}_1^t$, we can compute $\underset{\sim}{g}_j$ by making use of Eq. (37), and hence the moments $\underset{\sim}{f}(\tau_j; x)$; see Eq. (29).

3.4 Stabilizing Transformations: Our ability to evaluate the vector $\underset{\sim}{g}_1^t$ by making use of Eq. (38) depends upon the success of inverting the matrix $\left(\underset{\sim}{F}_J^b - \underset{\sim}{G}\,\underset{\sim}{F}_J^t\right)$. In many problems with $(L+1)$ of the order of 40 and higher and τ_b of the order of unity and greater, this inversion cannot be carried out successfully due to accumulation of round-off errors. Unfortunately, the problem of determining the effect of atmospheric dust on the estimated values of the total ozone from the measurements of the ultraviolet reflectivity of the earth-atmosphere system, falls into this latter category. For such cases, it is necessary to perform stabilizing transformations on the sequence $\underset{\sim}{F}_j$ and $\underset{\sim}{a}_j$. It should be remembered that the starting sequence $\underset{\sim}{F}_1$, $\underset{\sim}{a}_1$ is perfectly well-conditioned because its top halves are a unit matrix and a null vector, respectively [see the first equation in Eqs. (34) and (36)]. For our work, we have used the following criterion for selection of levels at which a stabilizing transformation will be performed on their corresponding $\underset{\sim}{F}_j$, $\underset{\sim}{a}_j$ sequence (the levels so selected are called conditioning points):

Maximum optical distance between two conditioning points $= y = \dfrac{10}{L+1}$.

For $\tau_b \leq 4.0$, and $(L+1) \leq 60$, $N_C = \dfrac{\tau_b}{y} + 4$.

For $\tau_b > 4.0$, and $(L+1) > 60$ but ≤ 80, $N_C = \dfrac{\tau_b}{y} + 14$.

For $\tau_b > 4.0$, and $(L+1) > 80$, $N_C = \dfrac{\tau_b}{y} + 30$.

Thus, for $\tau_b = 5.0$, and $(L+1) = 100$, this criterion will select 80 of the sublevels as conditioning points. Even for the case of $\tau_b < 0.1$ and $(L+1) \leq 10$, this criterion will ask for 4 conditioning points. From Dave and Canosa [1974], we see that this latter case requires only two conditioning points, one at $j = 1$, and the other at $j = J$. That is, Eq. (38) can be solved directly. Thus, the criterion used for determining the number of conditioning points here is somewhat stricter than the one used by us in our earlier work. This is for reducing the chances for a premature termination of the program.

The following discussion on the technique of the stabilizing transformation used is strictly a descriptive one, and is given primarily for understanding the mechanics of computations in the FORTRAN program SITBB: The reader interested in its mathematical aspects should refer to one of the several earlier publications on this subject [e.g., Canosa and Penafiel, 1973; Dave, 1974].

Let us serialize the levels selected as conditioning points as $C_1, C_2, \cdots, C_n$. C_1 is the level corresponding to the top of the atmosphere $(j = 1)$, and C_n is the level corresponding to the bottom of the atmosphere $(j = J)$. At C_1, the sequence $\underset{\sim}{F}_1, \underset{\sim}{a}_1$ is very well-conditioned by definition. Starting with this $\underset{\sim}{F}_1, \underset{\sim}{a}_1$ sequence, we generate the sequences $\underset{\sim}{F}_2, \underset{\sim}{a}_2, \underset{\sim}{F}_3, \underset{\sim}{a}_3, \cdots, \underset{\sim}{F}_j, \underset{\sim}{a}_j$, until we arrive at the sequence for the level corresponding to the conditioning point C_2. Let us call this sequence old $\underset{\sim}{F}_{C_2}$, old $\underset{\sim}{a}_{C_2}$. We then compute the following transformation matrix $\underset{\sim}{T}_{C_2}$ which is of the order $(L+1)/2 \times (L+1)/2$:

$$\underset{\sim}{T}_{C_2} = \left[\text{old } \underset{\sim}{F}_{C_2}^{t} \right]^{-1} . \tag{39}$$

The transformation of the old $\underset{\sim}{F}_{C_2}$ is then given by old $\underset{\sim}{F}_{C_2} \underset{\sim}{T}_{C_2}$ which will be referred to as $\underset{\sim}{U}_{C_2}$ matrix, or as a new $\underset{\sim}{F}_{C_2}$ matrix. The top half of this new $\underset{\sim}{F}_{C_2}$ matrix is a unit matrix while its bottom half is given by

$$\left[\text{new } \underset{\sim}{F}_{C_2} \right]^{b} = \underset{\sim}{U}_{C_2}^{b} = \left[\text{old } \underset{\sim}{F}_{C_2}^{b} \right] \underset{\sim}{T}_{C_2} . \tag{40}$$

The vector old $\underset{\sim}{a}_{C_2}$ is also to be transformed so that new $\underset{\sim}{a}_{C_2}$ is linearly independent of the columns of new $\underset{\sim}{F}_{C_2}$. This is achieved as follows:

(a) Store the top half of the old $\underset{\sim}{a}_{C_2}$ as $\underset{\sim}{t}_{C_2}$ for a future use, i.e.,

$$\underset{\sim}{t}_{C_2} = \text{old } \underset{\sim}{a}_{C_2}^{t} \tag{41}$$

(b) Compute another vector $\underset{\sim}{u}_{C_2}$ such that its top half is a null vector, and its bottom half is given by

$$\underset{\sim}{u}_{C_2}^{b} = \text{old } \underset{\sim}{a}_{C_2}^{b} - \underset{\sim}{U}_{C_2}^{b} \text{ old } \underset{\sim}{a}_{C_2}^{t} \tag{42}$$

(c) This $\underset{\sim}{u}_{C_2}$ vector is our new $\underset{\sim}{a}_{C_2}$ vector.

Summarizing, after performing stabilizing transformations on the old sequence $\underset{\sim}{F}_{C_2}$, $\underset{\sim}{a}_{C_2}$ at the second conditioning point, we have arrived at a new sequence $\underset{\sim}{F}_{C_2}$, $\underset{\sim}{a}_{C_2}$ such that this new sequence is very well-conditioned like the first sequence $\underset{\sim}{F}_{C_1}$, $\underset{\sim}{a}_{C_1}$. During this process, we have also generated $\underset{\sim}{U}^{b}_{C_2}$ and $\underset{\sim}{T}_{C_2}$ matrices which are of the order $(L+1)/2 \times (L+1)/2$, and $\underset{\sim}{u}^{b}_{C_2}$ and $\underset{\sim}{t}_{C_2}$ vectors which are of the length $(L+1)/2$. These two matrices are dependent upon the optical properties of the part of the atmospheric model contained between the first two conditioning points, while the vectors, in addition, are also dependent upon the parameter $x(= -\mu_0$, or iso).

A repetition of the procedure outlined above between the conditioning points C_2 and C_3 will result in generation of $\underset{\sim}{U}^{b}_{C_3}$, $\underset{\sim}{T}_{C_3}$, $\underset{\sim}{u}^{b}_{C_3}$, and $\underset{\sim}{t}_{C_3}$ vectors. Eventually, after marching through all atmospheric levels, we will have N_C number of these vectors and matrices.

The sequence $\underset{\sim}{U}^{b}_{C_n}$, $\underset{\sim}{u}^{b}_{C_n}$ is then used to compute a vector $\underset{\sim}{\ell}_{C_n}$ by solving the following system of linear equations:

$$\left(\underset{\sim}{U}^{b}_{C_n} - \underset{\sim}{G}\right)\underset{\sim}{\ell}_{C_n} = -\underset{\sim}{u}^{b}_{C_n} . \tag{43}$$

Since this $\underset{\sim}{\ell}_{C_n}$ vector corresponds $\underset{\sim}{g}^{t}_{J}$ [see Canosa and Penafiel, 1973], we have evaluated the entire vector $\underset{\sim}{g}_{J}$ or the moments $\underset{\sim}{f}(\tau_J; x)$ after making use of the lower boundary conditions.

Having obtained $\underset{\sim}{\ell}_{C_n}$ corresponding to the last conditioning point or the lowest level in the model, values of $\underset{\sim}{\ell}_{C_{k-1}}$ for the other conditioning points can be obtained by making use of the following equation:

$$\underset{\sim}{\ell}_{C_{k-1}} = \underset{\sim}{T}_{C_k}(\underset{\sim}{\ell}_{C_k} - \underset{\sim}{t}_{C_k}) . \tag{44}$$

Again, these $\underset{\sim}{\ell}_{C_k}$'s provide the top-half of $\underset{\sim}{g}_{j}$ vectors at levels where the conditioning points C_k are located. The bottom half of these $\underset{\sim}{g}_{C_k}$ vectors are then obtained as follows:

$$\underset{\sim}{g}_{C_k}^{b} = \underset{\sim}{U}_{C_k}^{b}\, \underset{\sim}{\ell}_{C_k} + \underset{\sim}{u}_{C_k}^{b} \,. \tag{45}$$

Having obtained values of $\underset{\sim}{g}_j$ vectors at all levels at which stabilizing transformations were performed, values of $\underset{\sim}{g}_j$ at levels in between the two successive conditioning points can be obtained by making use of the following equation:

$$\underset{\sim}{g}_j = \underset{\sim}{\Pi}_{j-1}\, \underset{\sim}{g}_{j-1} + \underset{\sim}{D}_{j-1,j}^{-1}\, \underset{\sim}{w}_{j-1} \,. \tag{46}$$

3.5 <u>Computations of the Intensity</u>: Having computed the Legendre moments of the azimuth-independent component of intensity [Eq. (12)] for all given directions of illumination of the atmospheric model from the outside, values of the quantity $I(\tau = 0; \mu, x)$ can be computed with the following equation:

$$I(\tau = 0; \mu, x) = \sum_{\ell=0}^{L} \frac{2\ell + 1}{2}\, f_\ell(\tau = 0)\, P_\ell(\mu) \,. \tag{47}$$

If this expression can provide accurate and smooth I vs. μ curves, we do not need computations of $\underset{\sim}{g}_j$ at all levels. It would be sufficient to have values of $\underset{\sim}{g}_1$ only. Thus, the steps represented by Eqs. (45) and (46) would be unnecessary.

However, values of $I(\tau = 0; \mu, x)$ so obtained are for the first $L + 1$ terms of the Legendre series representing the scattering phase function of a unit volume. As mentioned in the third paragraph of §2.4, the Legendre series for some aerosol distributions may require as many as 200 (or even 300 in some extreme case) terms, while the order of spherical harmonics approximation used varies between 40 and 100 depending upon the anisotropy of the phase function (§4.4). Even if the order of the spherical harmonics approximation was to be increased to account for all the terms in the input phase function, the curve $I(\tau = 0; \mu, x)$ vs. μ would still exhibit an oscillatory character [e.g., Dave and Canosa, 1974]. Dave and Armstrong [1974] have applied two different methods for smoothing the $I(\tau; \mu, x)$ vs. μ curves obtained with a given order of the spherical harmonics approximation. One of the methods is the Cesâro summation method which provides smooth curves but the actual accuracy of the computed intensities is of somewhat poor quality. The other method, known as the integration-of-the-source-function method, provides results more accurate compared to those obtained with the Cesâro summation method.

For our work, we will adopt a modified version of this integration-of-the-source-function method [Dave, 1975]. Accordingly, the source function $J(\tau_j; \mu, -\mu_0)$ due to virtual emission at the center of the τ_j-th layer, and in the direction μ, is given by

$$J(\tau_j; \mu, -\mu_0) = \frac{1}{4} F\, 0.5[e^{-\tau_j/\mu_0} + e^{-\tau_{j+1}/\mu_0}]$$

$$\times \sum_{\ell=0}^{LMX} \Lambda_\ell(\tau_j)\, P_\ell(\mu)\, P_\ell(-\mu_0) + \frac{1}{2} \sum_{\ell=0}^{L} \Lambda_\ell(\tau_j)$$

$$\times\, 0.5[f_\ell(\tau_j; -\mu_0) + f_\ell(\tau_{j+1}; -\mu_0)]\, P_\ell(\mu)\,, \quad (48)$$

and the source function due to the illumination condition $x = \text{iso}$ is given by

$$J(\tau_j; \mu, \text{iso}) = \frac{1}{2} \sum_{\ell=0}^{LMX} \Lambda_\ell(\tau_j) P_\ell(\mu)$$

$$\times 0.5 \left[\int_0^1 e^{-(\tau_b - \tau_j)/\mu_1} P_\ell(\mu_1) \, d\mu_1 \right.$$

$$\left. + \int_0^1 e^{-(\tau_b - \tau_{j+1})/\mu_1} P_\ell(\mu_1) \, d\mu_1 \right]$$

$$+ \frac{1}{2} \sum_{\ell=0}^{L} \Lambda_\ell(\tau_j) \; 0.5 \left[f_\ell(\tau_j; \text{iso}) + f_\ell(\tau_{j+1}; \text{iso}) \right]$$

$$\times P_\ell(\mu) \, . \tag{49}$$

The first term on the right hand side of Eqs. (48) and (49) represents a contribution due to the scattering of the direct solar radiation, and isotropic ground-reflected radiation, respectively. In other words, it represents the contribution due to the first (primary) scattering of the incoming direct radiation. This primary scattering contribution is computed after taking into account all terms of the Legendre series as the upper limit LMX assumes a value of 2 for a pure Rayleigh model, and is equal to greater of NMXST-1 and NMXTP-1 when the model contains stratospheric as well as tropospheric aerosols.

The second term on the right hand side of Eqs. (48) and (49) represents the contribution due to rescattering of the atmospheric radiation.

This higher-order contribution to the source function is computed using the P_L-th approximation.

Values of $I(\tau = 0; \mu, x)$ are then obtained by making use of the following series:

$$I(\tau = 0; \mu, x) = \frac{1}{\mu} \sum_{j=1} \overline{\exp(-\tau_j/\mu)\, J(\tau_j, \mu, x)}\, \Delta\tau_j \,, \tag{50}$$

where the bar implies the mean value of the terms under it.

IV. COMPUTATIONAL PROCEDURES

4.1 General: In §2, we mentioned that two computer programs (viz., SITAA and SITBB) are required for computing the azimuth-independent component of the intensity of the scattered radiation emerging from a nonhomogeneous, pseudo-spherical atmosphere. Computer requirements and the basic information for a successful running of these programs on an IBM 370 series computer were also given in that section. Some detailed information about the method of computations was given in §3. In the present section, we will give details about the programs themselves which are written in the FORTRAN IV language. This particular sub-section is restricted to some features common to both programs, and to giving a general idea about the contents of the remaining three sub-sections of this §4.

The input datasets in both programs are read in by the statement READ (IR, · · · · ·, where the parameter IR is assigned a value of unity in the beginning of the program (SITAA 25 and SITBB 148). The dataset intended as an input to a given program should therefore be made available on the disk assigned to the virtual machine with a file name of FILE, and a file type of FT01F001 before the program execution is called for.

The output intended in the printed form is written out by issuing a statement WRITE (IW, · · · · ·, where the parameter IW is assigned a value of 8 in the beginning (SITAA 26 and SITBB 149). In order to transfer this printer output to the printer disk-space of the host computer, it is necessary to issue the following file definition statement:

FI FT08F001 PRINTER (PERM RECFM UA BLKSIZE 132.

If not, the output will be stored on the disk attached to the virtual machine.

Subroutines from the FORTRAN library are accessed by issuing the statement GLOBAL TXTLIB FORTLIB before starting the execution of the program.

A subroutine TIMDAT is used to obtain information about the virtual and real CPU (Central Processing Unit) time, in seconds, required for a given production run. This subroutine has four arguments, viz., DATE, HOUR, ITV, and ITR. The arguments DATE and HOUR are in eight byte length (Real * 8). Readings of the virtual and real clocks in milliseconds are stored in the 4-byte integer locations ITV and ITR, respectively. The subroutine TIMDAT is called just before starting the main bulk of computations, and also just after all computations are completed for a given subset of the job. The differences between these two clock-readings are converted in seconds, and this timing information along with other identifying information of interest, is typed out at the terminal by issuing the statement WRITE (6, · · · · . This timing part of the program can be deleted without affecting the results of computations in any manner (statements numbered SITAA 22, 23, 40, 128 to 131, and SITBB 129, 130, 188, as well as 654 to 657).

Except for the subroutine TIMDAT discussed in the preceding paragraph, the program SITAA does not call for any subroutine unavailable in the standard FORTRAN library. On the other hand, the program SITBB does call for a number of such subroutines. Eight of these subroutines (viz., BCMAT, FLUX, LEGFUN, PITRIX, POLATE, SLPTH, SOLISY, and SOLVE) are discussed in §4.3. Remaining subroutines (viz., SUBSTA, SUBSTB, · · ·, SUBSTM) consist of a group of statements pulled out of the original version of the SITBB program primarily for the purpose of decreasing the CPU time required for several test runs. The functions performed by this latter type of subroutines are discussed at appropriate places in §4.4. Reader may come across two different SUBSTx routines performing essentially the same task.

4.2 Program SITAA: The statements numbered SITAA 1 through SITAA 23 contain comment cards, dimension statements for the various variables appearing in the main body of the program, and the format statements for handling input and output. The statement no. SITAA 24 defines the format for the direct access output file number 15; it will consist of

101 records of 2004 bytes each. The third parameter inside the parenthesis, viz., the letter L, specifies that the preceding number is in bytes. The last parameter is a dummy parameter of little interest to us. This DEFINE FILE statement must be compatible with the file definition statement given in §2.1.

Values of the variables TAU, SUM, and BUM (see Table I) are initialized during execution of the statements SITAA 28 through SITAA 32, and the constants appearing in recursive computations of $P_\ell(\mu)$ starting with values of $P_0(\mu)$ and $P_1(\mu)$ are evaluated during execution of the statements numbered SITAA 33 through SITAA 38.

Table I. Some important variables appearing in the SITAA program and their mathematical equivalents.

Variable	Mathematical Equivalent
AMU	μ
BUM	single precision representation of the integral appearing in §2.2.
COKA to COKC	numerical constants in recursive computations of $P_\ell(\mu)$
DMU	$\Delta\mu$
FNEX	$\exp(-\tau/\mu)$
FNPL	$P_\ell(\mu)$
SUM	double precision representation of the integral appearing in §2.2.
TAU	τ
ZPL	zeroes of $P_\ell(\mu)$ for a given value of the subscript ℓ.

Positions of the zeroes of $P_\ell(\mu)$ for the value of the subscript ℓ under investigation are read in (SITAA 43 through SITAA 52) only if the value of the subscript ℓ exceeds unity. A check is also made to see that the cards containing values of the zeroes of $P_\ell(\mu)$ are in proper order (SITAA 47).

Statements SITAA 53 through SITAA 71 are used to divide the interval between two consecutive positions of the zeroes of $P_\ell(\mu)$ in an even number of subintervals of equal length. This is because contribution to the integral from the interval contained between two consecutive positions of the zeroes of $P_\ell(\mu)$ is to be evaluated at a later stage by using Simpson's rule of integration. Care is taken to see that each interval is subdivided as finely as possible provided the total number of subintervals in the entire range (0.0 - 1.0) does not exceed 500. During the execution of these statements, the following quantities are also evaluated: μ_i at which the integrand $\exp(-\tau/\mu_i)\,P_\ell(\mu_i)$ will be evaluated, the subinterval $\Delta\mu_i = \mu_{i+1} - \mu_i$, and the quantity RAMU(I) representing $\exp(-0.01/\mu_i)$.

Values of $P_\ell(\mu_i)$ for all values of μ_i are computed during execution of the statements numbered SITAA 72 through SITAA 93 by making use of the well-known, upward recursion formula. The function $\exp(-\tau_j/\mu_i)$ for values of τ_j given by $\tau_j = 0.00\,(0.01)\,5.00$ and $j = 1\,(1)\,501$ is computed in the part of the program contained between SITAA 94 and SITAA 104. This exponential function is set to zero if its value is found to be smaller than 1.0×10^{-60} for a given τ_j, μ_i combination; this is done for avoiding any undesirable underflow messages at a later stage.

Statements SITAA 105 through SITAA 125 are used to evaluate the contribution to the exponential integral in each of the intervals using Simpson's rule, and then for evaluation of the integral over the entire range. All these computations are carried out using double precision arithmetic procedures. However, only values of the exponential integral rounded to about first seven significant figures (SITAA 124), are stored for all 501 values of the parameter τ and a given value of the subscript ℓ as a record number $\ell + 1$ on the dataset 15 (SITAA 127).

The program is then returned to the statement no. SITAA 39 for performing computations for the next higher value of the subscript ℓ. If an end of file is encountered during the reading of zeroes of $P_\ell(\mu)$, the control is transferred from SITAA 45 to SITAA 134. The remaining part of the program is then used to generate a printed output of values of the exponential integral for 501 equally spaced values of the parameter τ and for all successive integer values of the subscript ℓ, starting with zero.

4.3 Subroutines called by SITBB: As mentioned in the last paragraph of §4.1, we will describe the following subroutines in this section: BCMAT, FLUX, LEGFUN, PITRIX, POLATE, SLPTH, SOLISY, and SOLVE.

Subroutine BCMAT: This subroutine is called by the statement no. SITBB 182 of the main program for returning computed values of the vectors AL, AR, and the matrix GMAT. The vectors AL and AR represent the arrays on the left and right hand side of the main diagonal of the matrix on the right hand side of Eq. (14), respectively. The matrix GMAT represents elements of the boundary condition matrix $\underset{\sim}{G}$ first appearing at the Eq. (24). Explicit expressions for computations of all elements of this $\underset{\sim}{G}$ matrix can be found in §3.5 of a report by Dave [1974]. The calling program is written to accommodate up to P_{99}-th approximation of the Spherical Harmonics Approximation, and hence the orders of $\underset{\sim}{A}$ and $\underset{\sim}{G}$ matrices are 100 and 50, respectively. This subroutine is written to return values for these largest, called-for conditions. This subroutine is too small and too simple to require any further explanation.

Subroutine FLUX: This subroutine is called by the statement no. SITBB 570 and SITBB 587 for returning values of the direct solar flux $[F_s(\tau; x)]$, and upward as well as downward diffuse fluxes $[F_u(\tau; x)$ and $F_d(\tau; x)]$ at the level τ for all eleven cases of illumination of the atmospheric model under investigation. Mathematical equivalences of key variables appearing in this subroutine are given in Table II. The variable ISW carries information about the success or failure in computations of the $\underset{\sim}{g}$ vector [see Eq. (29)] corresponding to the lowermost level in the atmospheric model by making use of the Eq. (43). In the case of failure for a given case of illumination, F_u and F_d are set to zero.

Computations of $F_d(\tau; x)$ and $F_u(\tau; x)$ (with $x = -\mu_0$ or iso) are carried out by making use of Eqs. (47) and (48), respectively, given in a report by Dave [1974]. For these computations, we require values of the moments $f_\ell(\tau; x)$ defined by Eq. (12). It should be pointed out that locations VECL1 contain values of the $\underset{\sim}{g}$ vector at the level τ (symbol L in this subroutine) for all eleven cases of illumination,

Table II. Some important variables appearing in the subroutine FLUX and their mathematical equivalent.

Variable	Mathematical Equivalent
AMUO	μ_0
ATEN	$-\exp(-\tau/\mu_0)$; see Eqs. (19 - 22)
FXD	$F_d(\tau; -\mu_0)$ or $F_d(\tau; \text{iso})$
FXN	Net flux, $F_n(\tau; -\mu_0)$ or $F_n(\tau; \text{iso})$
FXS	$F_s(\tau, -\mu_0)$ or $F_g(\tau; \text{iso})$
FXU	$F_u(\tau; -\mu_0)$ or $F_u(\tau; \text{iso})$
L	level number
NTR	Order of the Sp. H. Approx. + 1
VECL1	$\underset{\sim}{g}$ vector at the level τ

and furthermore, the $\underset{\sim}{g}$ vector is essentially an $\underset{\sim}{f}$ vector rearranged as shown by Eq. (29). Hence, location VECL1(1, N) contains value of the moment $f_0(\tau)$ for the N-th case of illumination, while the location VECL1(NTR/2 + 1, N) contains the value of the moment $f_1(\tau)$ for the N-th case of illumination. The remaining even moments, i.e., $f_2(\tau; x)$, $f_4(\tau; x)$, $\cdots$, $f_{L-1}(\tau; x)$, required for computations of the diffuse fluxes are found in the location VECL1(2, N), VECL1(3, N), $\cdots$, VECL1 (NTR/2, N), respectively. With this explanation, one should have no difficulty in following statements no. FLUX 18 through FLUX 27.

The algebraic summations of $f_\ell(\tau)$ carried out during the execution statements FLUX 18 through FLUX 27 provide values of $-F_d(\tau; x)/2\pi$ and

$F_u(\tau; x)/2\pi$. Therefore, these sums are multiplied by appropriate factors to obtain values of $F_d(\tau; x)$ and $F_u(\tau; x)$; statements no. FLUX 28 and FLUX 29.

Computations of $F_s(\tau; -\mu_0)$ given by the expression $\pi \mu_0 \exp(-\tau/\mu_0)$ are carried out during execution of the statements FLUX 31 through FLUX 33. Values of $F_g(\tau; \text{iso})$ for the case of isotropic illumination from below are provided by the calling program in locations FXS(L, 11).

Values of the net flux $F_n(\tau; x)$ for $x = -\mu_0$ and $x = \text{iso}$ are then computed by the statements FLUX 35 and FLUX 37, respectively, by making use of the following equations:

$$F_n(\tau; -\mu_0) = F_s(\tau; -\mu_0) + F_d(\tau; -\mu_0) - F_u(\tau; -\mu_0) , \tag{51}$$

and

$$F_n(\tau; \text{iso}) = F_g(\tau; \text{iso}) + F_u(\tau; \text{iso}) - F_d(\tau; \text{iso}) . \tag{52}$$

<u>Subroutine LEGFUN</u>: This subroutine is called by the statement no. SITBB 181 for returning values θ_0, μ_0, $P_\ell(-\mu_0)$, θ, μ, and $P_\ell(\mu)$. These six quantities are represented by the symbols THETO, AMUO, FNYN, THETA, AMU, and FNYP, respectively. Ten input values of θ_0 are initialized by the statement no. LEGFN 10 and LEGFN 11. Numerical constants needed in recursive evaluation of the Legendre polynomials $P_\ell(\mu)$ starting with the values of $P_0(\mu)$ and $P_1(\mu)$, are computed during the execution of statements LEGFN 14 through LEGFN 21. Values of μ_0, and of $P_\ell(-\mu_0)$ for $\ell = 0\,(1)\,299$, are computed in the part of the program contained between the statements LEGFN 22 through LEGFN 37.

Equation (1) is used to compute values of values of θ and μ for the 18 different directions of observation for the NIMBUS-G configuration (LEGFN 40 through LEGFN 46). Remaining part of the subroutine deals with recursive evaluation of $P_\ell(\mu)$ for all 18 values of μ, and 300 values of the subscript ℓ.

Subroutine PITRIX: This subroutine is called by the statement no. SITBB 482 for obtaining values of all elements of the $\underset{\sim}{\pi}_j$ and $\underset{\sim}{D}^{-1}_{j,j+1}$ matrices given by Eqs. (35) and (33), respectively. The fourth and sixth arguments, viz., PIMAT and DINV, specify respective matrix locations at which values of $\underset{\sim}{\pi}_j$ and $\underset{\sim}{D}^{-1}_{j,j+1}$ for the j-th layer will be returned. The first and third arguments of this subroutine (viz., AL and AR) specify the nonvanishing elements of the bidiagonal matrix $\underset{\sim}{A}$ (see subroutine BCMAT). Values of the diagonal elements of the matrix $\frac{1}{2}\Delta\tau_j\, \underset{\sim}{C}(\tau_j + \frac{1}{2}\Delta\tau_j)$ appearing in Eqs. (32) and (33) [also see Eqs. (15) and (16)] are given by the second argument of this subroutine. The last argument, viz., NMX specifies the order of the input and output matrices. The remaining arguments provide the temporary work area.

From Eqs. (32), (33), and (35), we find that the computations of the $\underset{\sim}{\pi}_j$ matrix require values of $\underset{\sim}{D}^{-1}_{j,j+1}$ and $\underset{\sim}{D}_{j,j}$ matrices which, in turn, are tridiagonal matrices with their columns rearranged by parity. From the §5.4 of a report by Dave [1974], we find the following:

$$\underset{\sim}{D}^{-1}_{j,j+1} = \mathrm{Row}\left[\underset{\sim}{A} + \frac{1}{2}\,\Delta\tau_j\,\underset{\sim}{C}(\tau_j + \frac{1}{2}\Delta\tau_j)\right]^{-1}, \qquad (53)$$

and

$$\underline{\pi}_j = -\underline{D}^{-1}_{j,j+1}\underline{D}_{j,j}$$

$$= -\text{ Row} \cdot \text{Column}\left[\underline{I} - 2[\underline{A} + \frac{1}{2}\Delta\tau_j\,\underline{C}(\tau_j + \frac{1}{2}\Delta\tau_j)]^{-1}\,\underline{A}\right], \qquad (54)$$

where a Row operator on a matrix denotes the rearrangement of its rows by parity. This Row operator is similar to the Column operator which is described in the paragraph following Eq. (33) except that this new operator operates on rows, and not on columns of the matrix.

From the preceding discussion, it is clear that the task of computing elements of $\underline{\pi}_j$ and $\underline{D}^{-1}_{j,j+1}$ matrices reduces to that of inverting the tridiagonal matrix inside the rectangular bracket in Eq. (53) or (54). Inversion of a matrix (general or tridiagonal) can be best carried out after obtaining its $\underline{L} \cdot \underline{U}$ decomposition, i.e., after breaking it up into a lower triangular matrix $\underline{L}$, and an upper triangular matrix $\underline{U}$. Using Gaussian elimination procedure, one can easily obtain an $\underline{L} \cdot \underline{U}$ decomposition of a tridiagonal matrix provided no pivoting is required [Ch. XIII in Forsythe and Moler, 1967]. However, we find that an $\underline{L} \cdot \underline{U}$ decomposition of the above-mentioned tridiagonal matrix does require some partial pivoting. The procedure described in Chapters IX and XI of the book on "Computer Solution of Linear Algebraic Systems" by Forsythe and Moler cited above, for $\underline{L} \cdot \underline{U}$ decomposition of a general square matrix was appropriately modified to take advantage of the tridiagonality of the matrix at hand. This decomposition is carried out by the part of this subroutine contained between the statements PITRX 30 and PITRX 110. This part of the subroutine can be followed by referring to the book of

Forsythe and Moler, and partially pivoting a small (8×8) matrix manually. On analysis of this part of the subroutine, a reader would find that some extra precautions are taken to err on the safe side. Naturally, this does result in a small increase in the computational load. The $\underset{\sim}{L} \cdot \underset{\sim}{U}$ decomposition is stored at the matrix location TEM.

Statements PITRX 111 through PITRX 158 are then used to obtain an explicit inverse of the tridiagonal matrix at hand by making use of its recently-arrived-at $\underset{\sim}{L} \cdot \underset{\sim}{U}$ decomposition as follows:

Consider linear systems of equations given by $\underset{\sim}{A}\,\underset{\sim}{x}_i = \underset{\sim}{b}_i$ with $i = 1, 2, \cdots,$ NMX. The $\underset{\sim}{b}_i$-th vectors are so defined that all elements of the $\underset{\sim}{b}_k$-th vector have a zero value except for its k-th element which has a vaule of unity. Since $\underset{\sim}{L} \cdot \underset{\sim}{U}$ decomposition of $\underset{\sim}{A}$ is available, we can evaluate $\underset{\sim}{x}_i$ vector in two steps. [Note that $\underset{\sim}{A}$ of this paragraph is not the $\underset{\sim}{A}$ of Eq. (14).]

(i) Forward substitution: $\underset{\sim}{U}\,\underset{\sim}{x}_i = \underset{\sim}{L}^{-1}\,\underset{\sim}{b}_i$ PITRX 124 through PITRX 141, and

(ii) Backward substitution: $\underset{\sim}{x}_i = \underset{\sim}{U}^{-1}[\underset{\sim}{L}^{-1}\,\underset{\sim}{b}_i]$, PITRX 145 through PITRX 157.

The solution vector $\underset{\sim}{x}_i$ so obtained represents the i-th column of $\underset{\sim}{A}^{-1}$ matrix as $\underset{\sim}{A}\,\underset{\sim}{A}^{-1} = \underset{\sim}{I}$.

A reader desiring further information on this subject is referred to Forsythe and Moler's book mentioned above. It may be noted that an inverse of $[\underset{\sim}{A} + \frac{1}{2}\Delta\tau_j\ \underset{\sim}{C}(\tau_j + \frac{1}{2}\Delta\tau_j)]$ is stored at the matrix location

PIMAT at the conclusion of the statement no. PITRX 158.

Statements PITRX 165 through PITRX 178 are then used to perform a Row operation on $\left[\underset{\sim}{A} + \frac{1}{2}\Delta\tau_j \underset{\sim}{C}(\tau_j + \frac{1}{2}\Delta\tau_j)\right]^{-1}$ to obtain $\underset{\sim}{D}^{-1}_{j,j+1}$; see Eq. (53).

Finally, statements PITRX 182 through 193 are used to obtain the matrix appearing inside the outer large parenthesis in Eq. (54); and statements PITRX 197 - PITRX 209 and PITRX 210 - PITRX 222 are used to perform a column and a row transfer, respectively, for obtaining $\underset{\sim}{\pi}_j$ matrix in the matrix location TEM. The last part of this subroutine is used to transfer the $\underset{\sim}{\pi}_j$ matrix from the matrix location TEM to the matrix location PIMAT.

Subroutine POLATE: This subroutine is called by the statements SITBB 445 and SITBB 452 of the main program for returning linearly interpolated value of a function YTAB at a value X when the function YTAB is tabulated at an interval of 0.01 in the parameter x starting with 0.0. The interpolated value is returned at the location of the third argument of this subroutine, viz., Y.

Subroutine SLPTH: This subroutine is called by the statement no. SITBB 183 for returning values of the quantity $\Delta s_{i,j}$ [Eq. (22)] for all 10 values of θ_0, and for all 32 basic layers. The heights of bases of each of the 32 basic layers, and of the top of the atmosphere, are defined by the statements SLPTH 8 through SLPT 10. It should be noted that no attempt is made to compare these values with input values of

GTH (SITBB 157), or with the value of the radius of the earth in the subroutine LEGFUN. For another planet or for any other division of the atmosphere, proper care must be exercised.

Signs of the quantity μ_0 are changed (SLPTH 21) as values of μ_0 generated by the subroutine LEGFUN carry a negative sign before them. Again, this subroutine is too simple to require any detailed explanation.

Subroutine SOLISY: This subroutine is called by the statements SITBB 501 and SITBB 536 of the main program. It has 11 arguments. The first argument (viz., NCASE) can have a value of 1, or 2 only. For NCASE = 1, this subroutine returns an inverse of a general square matrix $\underset{\sim}{A}$ (second argument) in the matrix location designated AINV (third argument). For NCASE = 2, a linear system of equations $\underset{\sim}{A}\,\underset{\sim}{x} = \underset{\sim}{b}$ is solved [$\underset{\sim}{b}$ vector in the vector location designated B (sixth argument), and $\underset{\sim}{x}$ vector in the vector location designated X (fifth argument)]. The order of the $\underset{\sim}{A}$ matrix is given by the eighth argument, viz., NMX.

The remaining arguments supply a temporary work area to the subroutine except the ninth argument, ITR. Information transmitted to the calling program by this ninth argument, will be described at a later stage.

For NCASE = 1 or 2, the first step is to obtain an $\underset{\sim}{L}\cdot\underset{\sim}{U}$ decomposition of the matrix $\underset{\sim}{A}$ in the matrix location designated TEM (SOLIS 35 through SOLIS 82). The Gaussian elimination procedure with partial pivoting (see discussion under subroutine PITRIX in the preceding paragraphs) is used for this purpose.

The next step is to solve the linear system of equations $\underset{\sim}{A}\,\underset{\sim}{x} = \underset{\sim}{b}$ (NCASE = 2), or systems of linear equations $\underset{\sim}{A}\,\underset{\sim}{x}_i = \underset{\sim}{b}_i$, $i = 1, 2, \cdots,$ NMX for obtaining the matrix $\underset{\sim}{A}^{-1}$ (NCASE = 1). Again, reference is made to the discussion under the heading Subroutine PITRIX.

It should be pointed out that the matrix inverted in the subroutine PITRIX is a tridiagonal one. Hence, it is well-conditioned, and its inverse is assured against the propagation of round-off errors. On the other hand, the matrix to be inverted under this subroutine (SOLISY) is a general square matrix which may or may not be well-conditioned. Because of this, it is not sufficient for this subroutine to return numbers which may or may not truly represent the exact inverse of $\underset{\sim}{A}$. This subroutine should also measure the condition of the matrix during computations and provide an appropriate message when the reliability of the results is in doubt. The procedure used for measuring the condition of the $\underset{\sim}{A}$ matrix is described in Ch. XIII of the book by Forsythe and Moler [1967]. In brief, this procedure is as follows:

(i) Obtain a first solution of the linear system of equations $\underset{\sim}{A}\,\underset{\sim}{x} = \underset{\sim}{b}$ by following the procedure outlined under the heading Subroutine PITRIX. Call this first solution vector $\underset{\sim}{x}^{(1)}$. This solution is obtained by calling the subroutine SOLVE at the stage SOLIS 94. It should be again pointed out that for NCASE = 2, the system $\underset{\sim}{A}\,\underset{\sim}{x} = \underset{\sim}{b}$ is solved for only one value of the $\underset{\sim}{b}$

vector while for NCASE = 1, it is solved for a set of vectors $\underset{\sim}{b}_i$ with $i = 1, 2, \cdots,$ NMX where the $\underset{\sim}{b}_k$-th vector has all its elements set to zero except its k-th element which has a value of unity (SOLIS 83 through SOLIS 93).

(ii) Terminate the program with an appropriate message if $\underset{\sim}{x}^{(1)}$ is a null vector (SOLIS 106 through SOLIS 113).

(iii) Form the residual vector $\underset{\sim}{r}^{(1)} = \underset{\sim}{b}^{(1)} - \underset{\sim}{b}$ (SOLIS 115 through SOLIS 122).

(iv) Solve the linear system $\underset{\sim}{A}\,\Delta\underset{\sim}{x}^{(1)} = \underset{\sim}{r}^{(1)}$ by calling the subroutine SOLVE (SOLIS 123).

(v) Compute $\underset{\sim}{x}^{(1)} + \Delta\underset{\sim}{x}^{(1)}$ and compare it with $\underset{\sim}{x}^{(1)}$ vector. If the largest absolute values of these two vectors agree within 3 significant figures, attempt to improve on $\underset{\sim}{x}^{(1)}$ by going through the steps which follow. Otherwise, return to the calling program with a negative value for the argument ITR (SOLIS 129 through SOLIS 133, and SOLIS 137 as well as SOLIS 138).

(vi) Accept the solution $\underset{\sim}{x}^{(1)}$ if the largest elements in $\underset{\sim}{x}^{(1)}$ and $\underset{\sim}{x}^{(1)} + \Delta\underset{\sim}{x}^{(1)}$ agree within six significant figures (SOLIS 134). If not, go to the next step.

(vii) Repeat steps (iii) to (vi) above by treating $\underset{\sim}{x}^{(1)} + \Delta\underset{\sim}{x}^{(1)}$ as $\underset{\sim}{x}^{(2)}$, and then obtaining $\underset{\sim}{r}^{(2)}$ and $\Delta\underset{\sim}{x}^{(2)}$.

The iterative procedure outlined in step (vii) above is set to be repeated for 15 times (SOLIS 103) at the most. If after 15 iterations, the solution vector cannot be improved within the preset criteria, a return is made to the calling program with ITR = 0 (SOLIS 135, SOLIS 136, SOLIS 139, and SOLIS 140). The six-significant-figure convergence criterion is based on the single precision accuracy of the 370 series computers.

If the linear system of equations $\underset{\sim}{A}\,\underset{\sim}{x} = \underset{\sim}{b}$ can be solved successfully (or if the matrix $\underset{\sim}{A}$ can be inverted successfully for NCASE = 1), an integer value between 1 and 15 is returned to the calling program via the argument ITR.

Subroutine SOLVE: This subroutine is called by statements SOLIS 94 and SOLIS 123 of the subroutine SOLISY. It receives $\underset{\sim}{L} \cdot \underset{\sim}{U}$ decomposition of a general square matrix $\underset{\sim}{A}$ at the location designated TEM (first argument), and a vector $\underset{\sim}{b}$ at the location designated B (third argument). The solution vector $\underset{\sim}{x}$ (location designated X; second argument) is obtained by going through the forward substitution procedure ($\underset{\sim}{U}\,\underset{\sim}{x} = \underset{\sim}{L}^{-1}\,\underset{\sim}{b}$), and then the backward substitution procedure $[\underset{\sim}{x} = \underset{\sim}{U}^{-1}(\underset{\sim}{L}^{-1}\,\underset{\sim}{b})]$.

4.4 Program SITBB: This is the main program used for computing the azimuth-independent component of the intensity of scattered radiation emerging at the top of a pseudo-spherical model of a terrestrial atmosphere. It consists of a total of 660 FORTRAN statements. Input to, and output from this program are discussed in §2.3 and 2.4, respectively. Mathematical equivalence as appearing in the text (§3) and/or definition of various important variables appearing in this program are given in Table III.

After comment, dimension and format statements (SITBB 1 through 140) we arrive at the block SITBB 141 - SITBB 147 which deals with the FORTRAN equivalence of the file definition statements listed in §2.1. The datafiles no. 11 and 12 are for storing the $\underset{\sim}{U}_{C_n}$ and $\underset{\sim}{T}_{C_n}$ matrices (§3.4) generated at each of the conditioning points. A provision is made to deal with a maximum of 101 conditioning points for a given run (SITBB 385 - SITBB 388) and hence, each of these files has a capability of accommodating 101 records. The size of each of these records is 10,000 bytes based on (50, 50) REAL * 4 dimension of these matrices (SITBB 22). Datafiles no. 13 and 14 similarly accommodate vectors $\underset{\sim}{t}_{C_n}$ and $\underset{\sim}{u}_{C_n}$ for eleven directions of illumination. Their dimensions are (50, 11) each and hence a record length of 2,200 bytes.

The contents of datafile no. 15 are described in §2.2 and 4.2.

Datafile no. 16 is to store output of $I(\lambda, \Omega, P, R=0, \theta, \theta_0)$, $T(\lambda, \Omega, P, \theta, \theta_0)$, and $\bar{S}(\lambda, \Omega, P)$ for all six wavelengths of interest to the NIMBUS-G configuration, and for up to 200 different atmospheric models [Eq. (2) and discussion following it]. It therefore consists of 200 records. Each record consists of the single precision (REAL * 4) quantities TITB(14), EIC(18, 10, 6), TIC(18, 10, 6), and SSBBRR(6); see SITBB 32, SITBB 33, and SITBB 647. Hence, the record length in bytes

Table III. Important variables appearing in the program SITBB and their mathematical equivalence or definition.

Variable	Equivalence or Definition
A	Temporary work area.
AJVD	Exponential integral for the subscript ℓ; §2.2.
AL	Vector on the left of the main diagonal in the matrix $\underset{\sim}{A}$; Eq. (14).
ALDA	λ
AMOMT	$f_\ell(\tau; x)$ for a given τ; Eq. (12).
AMU	μ; §3.1.
AMUO	μ_0; §3.1.
AR	Vector on the right of the main diagonal in the matrix $\underset{\sim}{A}$; Eq. (14).
ATEN	$-\exp(-\tau/\mu_0)$ or its equivalence in a spherical atmosphere; see discussion following Eq. (20).
AVECT	$\underset{\sim}{a}_j$; Eq. (36).
B	Temporary work area.
BABSST	$\bar{\beta}^{(a,\,ST)}$; Eq. (7).
BABSTP	$\bar{\beta}^{(a,\,TP)}$; Eq. (7).
BLDA	λ
BMOMT	$f_\ell(\tau; x)$ for a given τ; Eq. (12).
BREKA - BREKD	Equivalence for the core storage area of $\underset{\sim}{\pi}_j$ and $\underset{\sim}{D}^{-1}_{j,j+1}$ matrices.
BSCAST	$\bar{\beta}^{(s,\,ST)}$; Eq. (7).
BSCATP	$\bar{\beta}^{(s,\,TP)}$; Eq. (7).

Table III, continued

Variable	Equivalence or Definition
BTEN	$\exp(-\tau/\mu)$.
C	Temporary work area.
CAPLAM	$\Lambda_\ell^{(\tau)}$; Eq. (11).
CAPLX	$0.5\ \sigma_\ell(\tau)\,\Delta\tau_j$; Eq. (16).
CAPLY	$\underset{\sim}{w}_j$; Eq. (30).
CINV	$\underset{\sim}{F}_j^t$; Eqs. (34) and (38).
CIMAT	Inverse of $\underset{\sim}{F}_j^t$.
COFAR	$\Lambda_\ell^{(R)}$; Eq. (11).
COFAS	$\Lambda_\ell^{(ST)}$; Eq. (11).
COFAT	$\Lambda_\ell^{(TP)}$; Eq. (11).
D	Temporary work area.
DATE	Date of the computer run.
DELS	$\Delta s_{i,j}(-\mu_0)$; Eq. (22).
DINV	$\underset{\sim}{D}_{j,j+1}^{-1}$; also used for a temporary storage, SITBB 523.
DISTAN	y; §3.4.
DTAU	$\Delta\tau_j$.
DTAUH	$0.5\ \Delta\tau_j$.
EIC	$I(0;\mu)$ for 18 values of μ, 10 values of θ_0, and 6 values of λ.
EIN	$I(0;\mu)$ for 18 values of μ, 10 values of θ_0, and also for isotropic illumination from below; §3.5
FMAT	$\underset{\sim}{F}_j$; Eq. (34).
FNYN	$P_\ell(-\mu_0)$.
FNYP	$P_\ell(+\mu)$.

Table III, continued

Variable	Equivalence or definition
FXD	$F_d(\tau; x)$; §4.3, FLUX.
FXN	$F_n(\tau; x)$; Eqs. (51) and (52).
FXS	$F_s(\tau; -\mu_0)$ or $F_g(\tau; \mathrm{iso})$.
FXU	$F_u(\tau; x)$; §4.3, FLUX.
GMAT	$\underset{\sim}{G}$; Eq. (24).
GTH	Geometric thickness of a basic layer.
HOUR	Hour of the day read by the computer clock.
ICHCK	$ICHCK_j = 11$ means that the j-th sublayer is the top-most sublayer of a given basic layer; $ICHCK_j = 0$ means that it is not so.
ICPOS	Sublevel number of the conditioning point.
ILDA	Serial number of the wavelength; §2.3.
INEW	Sublevel number of a given conditioning point.
IP	Array used for carrying information on partial pivoting of a matrix.
IPITE	Basic layer number of a given sublayer.
IR	Read tape unit.
ISW	$ISW_n = 0$ implies a success in solving the system of linear equation for the n-th direction of illumination.
ITR	§4.3, SOLISY.
ITRB	Real CPU time in milliseconds at the beginning.
ITRE	Real CPU time in milliseconds at the end.
ITVB	Virtual CPU time in milliseconds at the beginning.
ITVE	Virtual CPU time in milliseconds at the end.
IW	Write tape unit.

Table III, continued

Variable	Equivalence or Definition
LIMU	Work area for PITRIX.
MXNLVL	Total number of sublevels.
MXNLYR	Total number of sublayers.
NBAS	Basic layer number.
NBAS1 - NBAS4	Record numbers for storing $\underset{\sim}{\pi}_j$ and $\underset{\sim}{D}_{j,j+1}^{-1}$ on the unit no. 17.
NBYLR	Total number of basic layers; §2.3.
NMOD	Model number; §2.3.
NMXST	Upper limit of $\Lambda_{\ell}^{(ST)}$.
NMXTP	Upper limit of $\Lambda_{\ell}^{(TP)}$.
NTR	Order of the spherical harmonics approximation plus one.
NTRA	NTR + 1.
NTR2	NTR/2.
NTR21	NTR2 + 1.
NUMCON	Total number of conditioning points.
NUMCO1	NUMCON - 1.
OMEGR	$\omega_R(\tau)$; Eq. (8).
OMEGST	$\omega_{ST}(\tau)$; Eq. (8).
OMEGTP	$\omega_{TP}(\tau)$; Eq. (8).
OZABS	α; Eq. (6).
OZOTH	Ozone amount in a basic layer.
PRTH	Pressure thickness of a basic layer.
PIMAT	$\underset{\sim}{\pi}_j$; Eq. (35).

Table III, concluded

Variable	Equivalence or Definition
SBAR	$\bar{S}(\lambda, \Omega, P)$; Eq. (2).
SSBBRR	SBAR for all 6 wavelengths for a given model.
STDUST	Stratospheric dust content of a basic layer.
TAU	τ; Eq. (3).
TAUBSR	$\tau_b^{(s,R)}$; Eq. (4) or (5).
TAUTOT	τ_b
TEM	Temporary storage for a matrix.
TEMA - TEME	Temporary work area.
THETA	θ
THETO	θ_0
TIC	$T(\lambda, \Omega, P, \theta, \theta_0)$; Eq. (2); also §3.1, Intensity.
TIMR	Real CPU time in seconds.
TIMV	Virtual CPU time in seconds.
TITB	Title information.
TMAT	$\underset{\sim}{T}_{C_n}$; Eq. (39).
TPDUST	Tropospheric dust content of a basic layer.
TVECT	$\underset{\sim}{t}_{C_n}$; Eq. (41).
UMAT	$\underset{\sim}{U}^b_{C_n}$; Eq. (40).
UVECT	$\underset{\sim}{u}^b_{C_n}$; Eq. (42).
VECL1	$\underset{\sim}{\ell}_{C_n}$; Eq. (43).
VECL2	$\underset{\approx}{\ell}_{C_n}$; Eq. (43).
XBLNK	Variable to provide blank space in title.

is $4 \cdot [14 + (18 * 10 * 6) + (18 * 10 * 6) + 6]$, i.e., 8720. The parameters 18, 10, and 6 accommodate output for 18 values of θ, 10 values of θ_0, and 6 values of λ, respectively. The quantity TITB carries information about the basic atmospheric model.

Datafile no. 17 is created for temporary storage of values of $\underset{\sim}{\pi}_j$ and $\underset{\sim}{D}^{-1}_{j,j+1}$ matrices for each of 32 basic layers of the atmospheric model [Eqs. (35) and (33)]. These are single precision quantities of dimension 100×100 (SITBB 24). Thus, the required physical length of a record of either matrix for a given basic layer is 40,000 bytes. The maximum record length which the system can handle is 32K (1K = 1024 bytes) bytes. We have therefore broken up each full record in two physical records for writing and reading purposes. PIMAT matrix into BREKA and BREKB matrices, and DINV into BREKC and BREKD. Each of this BREKx record has a length of 20,000 bytes (SITBB 29 and SITBB 30). Equivalence between PIMAT, DINV, and BREKx are given by the statements no. SITBB 34 and SITBB 35.

The part of the program contained between statements SITBB 148 through SITBB 285 deals mainly with input and output which are discussed in §2.3 and 2.4, respectively. Quantities such as $\underset{\sim}{G}$, μ_0, μ, $\Delta s_{i,j}$, etc., which are independent of wavelength are also generated by calling appropriate subroutines (SITBB 177 - SITBB 183).

The section of this program contained between the statements SITBB 286 through SITBB 360 is used for dividing all basic layers into sub-layers whenever necessary, and for computing various optical properties of each of these sublayers. First, various optical thicknesses [viz., $\Delta\tau^{(s,R)}$, $\Delta\tau^{(a)}$, $\Delta\tau^{(s,ST)}$, $\Delta\tau^{(a,ST)}$, $\Delta\tau^{(s,TP)}$, $\Delta\tau^{(a,TP)}$, and $\Delta\tau$; see Eq. (3)] of each of the basic layers are computed during the execution of the statements no. SITBB 303 through SITBB 310. The next five statements are used to determine the number of sublayers into which a given basic layer will have to be subdivided for satisfying the criterion that total optical thickness of no sublayer will exceed 0.02. Statements SITBB 316 through SITBB 334 are then used to generate serial numbers of each of the sublayer, for computing their various albedoes [Eq. (8)] as well as optical thickness (DTAU), and for computing total optical depth (TAU) at their bases. The procedure is started with the topmost basic layer, and is terminated with an appropriate message if total number of sublayers required exceeds 300 (SITBB 322 - SITBB 325). The remaining statements in this section are used to initialize the vectors ICHCK and INEW (see Table III), and for computing attenuation suffered by the direct solar radiation as it arrives at bases of various sublayers from ten different directions (ATEN), as well as attenuation suffered by a ray while traveling through a sublayer from one of the 18 different directions (BTEN).

Statements numbered SITBB 366 through SITBB 380 are used to determine the order of the spherical harmonics approximation to be used for evaluating the multiple scattering contribution to the outgoing radiation. This is done by examining total number of terms in the Legendre series representing the normalized phase functions for scattering for both types of aerosols. Even in the absence of any type of aerosol, the P_{39}-th approximation is used.

The next step (SITBB 381 - SITBB 403) is to determine the number of conditioning points, and their locations in terms of sublevel number (ICPOS) as well as corresponding optical depth (TAU).

The subroutine SUBSTA is then called upon for returning values of the quantities CAPLAM, CAPLX, and CAPLY defined in Table III.

Statements SITBB 405 through SITBB 432 deal with computations of the primary-scattering contribution to $I(0; \mu, -\mu_0)$. The first term on the right hand side of Eq. (48) is substituted in Eq. (50) for this purpose. This primary-scattering contribution is computed by taking into account all (greater of the input parameters NMXST and NMXTP) terms of the Legendre series representing scattering phase function of aerosols. The series appearing on the right hand side of Eq. (48) has been evaluated in two parts, viz., SITBB 418 - SITBB 420, and SITBB 421 - SITBB 426. This is because the quantity CAPLAM is available for the first, NTR number of terms, only.

The next step is computations of the term $0.5\ \Delta\tau_j [s_\ell(\tau_j, \text{iso}) + s_\ell(\tau_{j+1}; \text{iso})]$ assuming $I_g(-\mu_0)$ to be equal to unity [see Eqs. (20) and (30)], and the primary-scattering contribution to the diffuse radiation emerging at the top when the model is illuminated by isotropic radiation from below [the first term on the right hand side of Eq. (49) substituted in Eq. (50)]. Computations of both of these terms require values of the exponential integral defined in §2.2, and stored in data-file no. 15. After reading in tabulated values of the integral for a given value of the subscript ℓ (SITBB 443), subroutine POLATE is called upon to return the interpolated value of the integral at a given value of τ. The first of the two terms listed in the beginning of this paragraph is stored in locations designated CAPLY(I, L, 11), while the second one is stored in locations designated EIN(J, 11). Completion of computations in this particular section (SITBB 433 through SITBB 462) also provide values of the directly transmitted upward flux due to isotropic illumination from below $\left\{2\pi \int_0^1 \exp[-(\tau_b - \tau)/\mu]\, \mu\, d\mu\right\}$ in locations designated FXS(L, 11).

The part of the program contained between statements no. SITBB 463 through SITBB 468 is used for initializing values of $\underset{\sim}{a}_1$ vectors for all eleven directions of illumination [Eq. (36)], and of the $\underset{\sim}{F}_1$ matrix [Eq. (34)] by calling the subroutine SUBSTB.

A very good portion of the computational load is contained in the next block, viz., SITBB 469 - SITBB 514. It essentially consists of a DO LOOP 400 whose purpose is to compute $\underset{\sim}{\pi}_j$ [Eq. (35)] and $\underset{\sim}{D}^{-1}_{j,j+1}$ [Eq. (33)] matrices for all sublayers of the atmospheric model under study (SITBB 477 - SITBB 494), and to perform the stabilizing transformations (§3.4) for those sublevels corresponding to one of the conditioning points (SITBB 499 - SITBB 513).

First the matrices $\underset{\sim}{D}^{-1}_{j,j+1}$ and $\underset{\sim}{\pi}_j$ for the j-th sublayer are evaluated by calling the subroutine PITRIX, only if this sublayer corresponds to the topmost sublayer of a basic layer (SITBB 477 - SITBB 482). If these matrices are evaluated, then their values are also stored on the datafile no. 17 (fifth paragraph in §4.4) by executing the next eight statements. Subroutine SUBSTC (SITBB 494) is then called to compute $\underset{\sim}{F}_j$ matrix [Eq. (34)], and $\underset{\sim}{a}_j$ vectors [Eq. (36)].

Second, for a sublevel corresponding to one of the conditioning points (SITBB 499), a stabilizing transformation is performed as follows:

(i) Call the subroutine SUBSTD (SITBB 500) for transferring the top-half of the $\underset{\sim}{F}_j$ matrix into a matrix location designated CINV.

(ii) Call the subroutine SOLISY (SITBB 501) for obtaining an explicit inverse of the matrix CINV in another matrix location designated CIMAT.

(iii) After printing information about the result of attempts to invert CINV, terminate the program in the case of a failure (see discussion of the argument ITR in the subroutine SOLISY).

(iv) Call the subroutine SUBSTE(SITBB 505) to generate $\underset{\sim}{U}C_n$ and $\underset{\sim}{T}C_n$ matrices (§3.4), and store their values on the datafiles no. 11 and 12, respectively.

(v) Call the subroutine SUBSTF(SITBB 509) to generate new $\underset{\sim}{F}_j$ matrix, i.e., the reconditioned one.

(vi) Call the subroutine SUBSTG(SITBB 510) to generate $\underset{\sim}{t}C_n$ and $\underset{\sim}{u}C_n$ vectors for all eleven directions of illumination, and store their values on datafiles no. 13 and 14, respectively.

Execution of the statements contained between SITBB 515 and SITBB 550 results in evaluation of the vector $\underset{\sim}{\ell}_{C_n}$ corresponding to the bottom-most conditioning point (lower-most level of the atmospheric model) by using Eq. (43). This vector $\underset{\sim}{\ell}_{C_n}$ is evaluated for each of the eleven directions of illumination, and the parameter ISW is set to a non-zero value in the case of a failure in solving the linear system of equations [Eq. (43)] for a given direction. The subroutine SUBSTH is used for transferring $\underset{\sim}{U}^{b}_{C_n}$ to a location designated DINV, and the subroutine SUBSTI is used for generating the bottom-half of $\underset{\sim}{g}_J$ vectors [Eq. (28)]. The quantity $\overline{S}(\lambda, \Omega, P)$ appearing in Eq. (2) is computed at the stage SITBB 551; also see Eq. (23).

The second number-crunching portion of the program is contained between the statements SITBB 556 through SITBB 605. Its first purpose is to evaluate g_j vectors at all conditioning-point levels of the model and for all eleven directions of illumination by making use of Eqs. (44) and (45). Its second purpose is to compute upward and downward diffuse fluxes (see subroutine FLUX), and the multiple-scattering contribution to the outgoing diffuse radiation [second term on the right hand side of Eqs. (48) and (49) substituted in Eq. (50)]. The direct transmission of the isotropic illumination from below is added to the outgoing diffuse radiation during execution of the statements no. SITBB 603 through SITBB 605.

The first purpose is served by the statements SITBB 557 through SITBB 567. The $\underset{\sim}{\ell}_{C_k}$ vectors appearing on the right hand side of Eq.

(44) are available at the locations designated VECL2. After reading in values of $\underset{\sim}{U}^{b}_{C_{k-1}}$ matrix and $\underset{\sim}{u}^{b}_{C_{k-1}}$ as well as $\underset{\sim}{t}_{C_k}$ vectors from the disk (SITBB 558 - SITBB 562), an entry is made in the subroutine SUBSTJ. Statements no. SUBTJ 9 through SUBTJ 18 are used for computing and storing values of the $\underset{\sim}{\ell}_{C_{k-1}}$ vectors at locations designated VECL1, and AVECT. At this stage, the AVECT locations contain the top-half of $\underset{\sim}{g}_j$ vectors at the level under scrutiny. The bottom-half of $\underset{\sim}{g}_j$ vectors is computed by making use of statements no. SUBTJ 20 through SUBTJ 26 if the conditioning point does not correspond to the top-most level of the model, and by making use of statements no. SUBTJ 28 through SUBTJ 35 if the conditioning point does correspond to the topmost level of the model. This is because, for this latter case, $\underset{\sim}{U}^{b}_{C_1} = -\underset{\sim}{G}$ by definition. The $\underset{\sim}{T}_{C_{k-1}}$ matrix is then read in for being ready for the next time around. At this stage, we have values of $\underset{\sim}{g}_j$ vectors at atmospheric sublevels where the conditioning points C_{k-1} and C_k are located.

The second purpose is served during execution of the statements no. SITBB 568 through SITBB 597. Subroutine FLUX is called at the stage SITBB 570 for computing values of various fluxes at the sublevel corresponding to the C_{k-1}-st conditioning point. Then an entry is made in the subroutine SUBSTK for storing values of $\underset{\sim}{g}_{C_{k-1}}$ vectors in the location designated AMOMT. The DO LOOP 800 (SITBB 573 - SITBB 590) is for evaluating $\underset{\sim}{g}_j$ vectors [Eq. (46)] for all sublevels located between the conditioning points C_{k-1} and C_k (subroutine SUBSTL, SITBB 586).* After obtaining $\underset{\sim}{g}_j$ vectors for a given sublevel intermediate between

*Footnote is on page 68.

the conditioning points C_{k-1} and C_k, fluxes at that sublevel are computed during execution of the statement no. SITBB 587. After a call to the subroutine SUBSTK(SITBB 588), we have values of $\underset{\sim}{g}_j$ vectors for two consecutive sublevels in locations designated AMOMT and BMOMT. We can therefore compute the multiple-scattering contribution to the outgoing radiation due to the scattering mass between these two sublevels, by calling the subroutine SUBSTM.

The last two sections of the program (SITBB 606 - SITBB 635, and SITBB 636 - SITBB 657) are used for generating the flux and intensity outputs described in §2.4. After this, the control is unconditionally

---

(Footnote from pg. 67)

*For evaluation of $\underset{\sim}{g}_j$ vectors between two consecutive conditioning points, we require values of $\underset{\sim}{\pi}_{j-1}$ and $\underset{\sim}{D}^{-1}_{j-1,j}$ matrices for all intermediate sublayers. However, if two consecutive sublayers are part of the same basic layer, their optical properties, and hence their $\underset{\sim}{\pi}_{j-1}$ and $\underset{\sim}{D}^{-1}_{j-1,j}$ matrices are exactly the same. (Because of this, values of these matrices stored on the disk are for the topmost sublayers of all basic layers, only.) Thus, values of these matrices are to be read in for the first value (LMIN) of the index L of the DO LOOP 800, or alternately, if the current sublayer has different optical properties from the preceding one. This objective is accomplished through the part of the program contained between statements no. SITBB 575 through SITBB 585.

transferred to the statement no. SITBB 187 for starting computations for the next wavelength, but for the same atmospheric model.

V. REFERENCES

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VI. LISTING OF THE FORTRAN STATEMENTS

6.1 Program SITAA: (See page 72.)

```
C                                                                       SITAA
C       PROGRAM FOR COMPUTING THE INTEGRAL                              SITAA
C       EXP(-TAU/MU) * P SUB L OF MU * DMU     OVER THE RANGE 0.0 TO 1.0 SITAA
C       AFTER DIVIDING THE RANGE AT ZERO-POSITIONS OF P SUB L,          SITAA
C       AND THEN INTEGRATING OVER EACH INTERVAL USING SIMPSON'S RULE..  SITAA
C                                                                       SITAA
      REAL * 8 TAU(501),ZPL(52),AMU(501),DMU(500),FNPL(501),SUM(501),   SITAA
     1 TEMA,TEMB,TEMC,TEME,TEMF,CONA,DATE,HOUR,FNEX(501),               SITAA
     2 COKA(100),COKB(100),COKC(100),RAMU(501)                          SITAA
      REAL * 4 BUM(501)                                                 SITAA
      INTEGER * 4 ILIM(52)                                              SITAA
   15 FORMAT (I5)                                                       SITAA
   20 FORMAT (5F10.7,16X,I4)                                            SITAA
   30 FORMAT (1H1//T20,'INTEGRAL EXP(-TAU/MU) * P SUB',I5,T56,          SITAA
     1 'OF MU * DMU FOR TAU EQUAL TO'/)                                 SITAA
   40 FORMAT (/T4,'TAU',T15,'0.00',T27,'0.01',T39,'0.02',T51,'0.03',    SITAA
     1 T63,'0.04',T75,'0.05',T87,'0.06',T99,'0.07',T111,'0.08',T123,    SITAA
     2 '0.09'/)                                                         SITAA
   50 FORMAT (0PF7.3,1P10D12.4)                                         SITAA
   55 FORMAT (0PF7.3,1P1D12.4)                                          SITAA
   70 FORMAT (//T20,'PROGRAM TERMINATED AS L AND LC ARE = ',2I5//)      SITAA
   80 FORMAT (/T3,'COMPLETED L = ',I5,T25,'VIRTUAL & REAL TIME IN SECS.'SITAA
     1 ,2F9.2/)                                                         SITAA
      DEFINE FILE 15 (101,2004,L,IPT)                                   SITAA
      IR = 1                                                            SITAA
      IW = 8                                                            SITAA
      READ (IR,15) L                                                    SITAA
      DO 95 N = 1,501                                                   SITAA
      TAU(N) = (N-1) * 1.0D-02                                          SITAA
      SUM(N) = 0.0D0                                                    SITAA
      BUM(N) = 0.0                                                      SITAA
   95 CONTINUE                                                          SITAA
      DO 98 J = 1,100                                                   SITAA
      COKA(J) = 2*J - 1                                                 SITAA
      COKB(J) = J - 1                                                   SITAA
      COKC(J) = 1.0D0/J                                                 SITAA
   98 CONTINUE                                                          SITAA
      CONA = 1.0D0/3.0D0                                                SITAA
  100 CONTINUE                                                          SITAA
      CALL TIMDAT (DATE,HOUR,ITVB,ITRB)                                 SITAA
      NZPL = (L/2) + 1                                                  SITAA
      ZPL(1) = 0.0D0                                                    SITAA
      IF ( NZPL .EQ. 1 ) GO TO 120                                      SITAA
      DO 110 I = 2,NZPL,5                                               SITAA
      READ (IR,20,END=1000) ZPL(I),ZPL(I+1),ZPL(I+2),ZPL(I+3),          SITAA
     1 ZPL(I+4),LC                                                      SITAA
      IF ( LC .EQ. L ) GO TO 110                                        SITAA
      WRITE (IW,70) L,LC                                                SITAA
      GO TO 1000                                                        SITAA
  110 CONTINUE                                                          SITAA
  120 CONTINUE                                                          SITAA
      ZPL(NZPL+1) = 1.0D0                                               SITAA
      NSUB = 500/NZPL                                                   SITAA
      NS = (NSUB/2) * 2                                                 SITAA
      IF ( NS .NE. NSUB) NSUB = NSUB - 1                                SITAA
```

```
      AMU(1) = 0.0D0
      I1 = 1
      ILIM(1) = 1
      TEME = 1.0D0/NSUB
      DO 160 K = 1,NZPL
      TEMA = (ZPL(K+1) - ZPL(K)) * TEME
      I2 = I1 + NSUB - 1
      ILIM(K+1) = I2 + 1
      DO 150 I = I1,I2
      DMU(I) = TEMA
      AMU(I+1) = AMU(I) + TEMA
      RAMU(I+1) = DEXP(-1.0D-02/AMU(I+1))
  150 CONTINUE
      I1 = I2 + 1
  160 CONTINUE
      IMAX = I1
      IF ( L .GT. 0 ) GO TO 170
      DO 165 I = 1,IMAX
      FNPL(I) = 1.0D0
  165 CONTINUE
      GO TO 200
  170 IF ( L .GT. 1 ) GO TO 180
      DO 175 I = 1,IMAX
      FNPL(I) = AMU(I)
  175 CONTINUE
      GO TO 200
  180 CONTINUE
      DO 198 I = 1,IMAX
      TEMA = 1.0D0
      TEMB = AMU(I)
      DO 195 J = 2,L
      TEMC = (COKA(J) * AMU(I) * TEMB - COKB(J) * TEMA) * COKC(J)
      TEMA = TEMB
      TEMB = TEMC
  195 CONTINUE
      FNPL(I) = TEMC
  198 CONTINUE
  200 CONTINUE
      DO 210 I = 1,IMAX
      FNEX(I) = 1.0D0
  210 CONTINUE
      DO 400 N = 1,501
      IF ( N .EQ. 1 ) GO TO 240
      FNEX(1) = 0.0D0
      DO 230 I = 2,IMAX
      FNEX(I) = FNEX(I) * RAMU(I)
      IF ( FNEX(I) .LT. 1.0D-60) FNEX(I) = 0.0D0
  230 CONTINUE
  240 CONTINUE
      SUM(N) = 0.0D0
      DO 300 J = 1,NZPL
      I1 = ILIM(J)
      I2 = ILIM(J+1)
      TEMB = DMU(I1)*CONA
      TEMA = FNEX(I1) * FNPL(I1) + FNEX(I2) * FNPL(I2)
```

```
      I1 = I1 + 1
      TEME = 0.0D0
      DO 260 I = I1,I2,2
      TEME = TEME + FNEX(I) * FNPL(I)
  260 CONTINUE
      I1 = I1 + 1
      I2 = I2 - 1
      TEMF = 0.0D0
      DO 280 I = I1,I2,2
      TEMF = TEMF + FNEX(I) * FNPL(I)
  280 CONTINUE
      SUM(N) = SUM(N) + TEMB * (TEMA + 4.0D0 * TEME + 2.0D0 * TEMF)
  300 CONTINUE
      BUM(N) = SUM(N)
  400 CONTINUE
      LK = L + 1
      WRITE (15'LK) BUM
      CALL TIMDAT (DATE,HOUR,ITVE,ITRE)
      TIMV = (ITVE - ITVB) * 0.001
      TIMR = (ITRE - ITRB) * 0.001
      WRITE (6,80) L,TIMV,TIMR
      L = L + 1
      GO TO 100
 1000 CONTINUE
      LMX = L
      DO 600 L = 1,LMX
      READ (15'L) BUM
      L1 = L - 1
      WRITE (IW,30) L1
      WRITE (IW,40)
      DO 500 I = 1,500,10
      WRITE (IW,50) TAU(I),(BUM(I+J-1),J=1,10)
  500 CONTINUE
      WRITE (IW,55) TAU(501),BUM(501)
  600 CONTINUE
      RETURN
      END
```

6.2 Subroutines called by SITBB: (See page 76.)

```
      SUBROUTINE BCMAT(GMAT,AL,AR)
C
C       PROGRAM FOR COMPUTING ALL ELEMENTS OF THE 50 BY 50 BOUNDARY
C       CONDITION MATRIX,G,,,, AND ELEMENTS OF THE BIDIAGONAL MATRIX A..
C
      REAL * 4 GMAT(50,50),AL(100),AR(100)
      TEMA = -0.5
      DO 110 J = 1,50
      L = J - 1
      GMAT(1,J) = TEMA
      DO 100 I = 2,50
      II = I - 1
      TEMB = ( -2*L + 2*II - 1) * (L + II) * (2*II + 1)
      TEMC = 2 * II * (2*L - 2*II - 1) * (L + II + 1)
      GMAT(I,J) = (TEMB * GMAT(II,J))/TEMC
  100 CONTINUE
      TEMB = (3 - 2*J) * (1 + 4*J)
      TEMC = (2*J + 2) * (4*J - 3)
      TEMA = (TEMA * TEMB)/TEMC
  110 CONTINUE
      DO 120 I = 1,100
      TEMA = 1.0/(2*I - 1)
      AL(I) = TEMA * (I - 1)
      AR(I) = TEMA * I
  120 CONTINUE
      RETURN
      END
      SUBROUTINE FLUX (AMUO,ATEN,VECL1,FXS,FXU,FXD,FXN,NTR,L,ISW)
C
C      SUBROUTINE FOR COMPUTING UPWARD AND DOWNWARD DIFFUSE
C      FLUXES AT A GIVEN LEVEL FROM VALUES OF THE MOMENTS....
C
      REAL * 4 VECL1(100,11),AMUO(10),ATEN(301,10),FXS(301,11),
     1 FXD(301,11),FXU(301,11),FXN(301,11)
      INTEGER * 4 ISW(11)
      DATA CONA /-6.283185/, CONB /-3.141593/
      NTR2 = NTR/2
      I1 = NTR2 + 1
      DO 150 N = 1,11
      IF ( ISW(N) .EQ. 0 ) GO TO 120
      FXU(L,N) = 0.0
      FXD(L,N) = 0.0
      GO TO 150
  120 CONTINUE
      TEMA = -0.25 * VECL1(1,N) + 0.5 * VECL1(I1,N)
      TEMB = 0.25 * VECL1(1,N) + 0.5 * VECL1(I1,N)
      TEMC = 0.5
      DO 130 J = 2,NTR2
      J1 = (J-1) * 2
      TEMC = ((3 - J1) * TEMC ) / (J1 + 2)
      TEMD = (J1 + 0.5 ) * TEMC * VECL1(J,N)
      TEMA = TEMA - TEMD
      TEMB = TEMB + TEMD
  130 CONTINUE
      FXD(L,N) = CONA * TEMA
```

```
      FXU(L,N) = 6.283185 * TEMB
  150 CONTINUE
      DO 160 N = 1,10
      FXS(L,N) = CONB * AMUO(N) * ATEN(L,N)
  160 CONTINUE
      DO 170 N = 1,10
      FXN(L,N) = FXS(L,N) + FXD(L,N) - FXU(L,N)
  170 CONTINUE
      FXN(L,11) = FXS(L,11) + FXU(L,11) - FXD(L,11)
      RETURN
      END
      SUBROUTINE LEGFUN (THETO,AMUO,FNYN,THETA,AMU,FNYP)
C
C       PROGRAM FOR COMPUTING LEGENDRE POLYNOMIALS FOR 28 (10 NEGATIVE,
C       AND 18 POSITIVE) DIFFERENT VALUES OF THEIR ARGUMENTS, MU...
C
      REAL * 4 THETO(10),AMUO(10),FNYN(300,10),THETA(18),AMU(18),
     1 FNYP(300,18)
      REAL * 8 DHETO(10),TEMA,TEMB,TEMC,TEMD,TEMX,TEME,COKA(300),
     1 COKB(300),COKC(300)
      DATA DHETO /0.0D0,45.0D0,60.0D0,70.0D0,75.6D0,79.6D0,82.5D0,
     1 84.7D0,86.7D0,90.0D0/
      TEMD = 3.1415926535897932/180.0D0
      TEME = 1.0/TEMD
      COKA(1) = -1.0D0
      COKB(1) = -1.0D0
      COKC(1) = 0.0D0
      DO 120 K = 2,300
      COKA(K) = 2*K - 3
      COKB(K) = K - 2
      COKC(K) = 1.0D0/(K-1)
  120 CONTINUE
      DO 150 I = 1,10
      THETO(I) = DHETO(I)
      TEMA = 1.0D0
      TEMB = -DCOS(TEMD * DHETO(I))
      IF ( DHETO(I) .EQ. 90.0D0 ) TEMB = 0.0D0
      AMUO(I) = TEMB
      FNYN(1,I) = TEMA
      FNYN(2,I) = TEMB
      TEMX = TEMB
      DO 130 K = 3,300
      TEMC = (COKA(K) * TEMX * TEMB - COKB(K) * TEMA)*COKC(K)
      TEMA = TEMB
      TEMB = TEMC
      FNYN(K,I) = TEMC
  130 CONTINUE
  150 CONTINUE
      DO 200 I = 1,18
      TEMA = 1.0D0
      TEMB = (7326.0D0/6371.0D0) * DSIN (TEMD * 3.0D0 * (I-1))
C
C       7326 = 6371 + 955 = RAD. OF EARTH + HEIGHT OF THE SATELLITE..
C
      TEMB = DSQRT(1.0D0 - TEMB * TEMB)
```

```
      AMU(I) = TEMB
      THETA(I)  = TEME * DARCOS(TEMB)
      FNYP(1,I) = TEMA
      FNYP(2,I) = TEMB
      TEMX = TEMB
      DO 180 K = 3,300
      TEMC = (COKA(K) * TEMX * TEMB - COKB(K) * TEMA)* COKC(K)
      TEMA = TEMB
      TEMB = TEMC
      FNYP(K,I) = TEMC
  180 CONTINUE
  200 CONTINUE
      RETURN
      END
      SUBROUTINE PITRIX (AL,AM,AR,PIMAT,TEM,DINV,X,B,IP,LIMU,NMX)
C
C       SUBROUTINE FOR OBTAINING VALUES OF THE ELEMENTS OF THE PI MATRIX
C       STARTING WITH ELEMENTS AL AND AR OF THE BIDIAGONAL MATRIX A,
C       AND ELEMENTS AM OF THE DIAGONAL MATRIX C..
C       N.B. : THE SCALAR FACTOR 0.5 * DELTA TAU IS TO BE INCLUDED
C       IN AM BEFORE CALLING THIS SUBROUTINE...
C
C       THIS PROGRAM ALSO RETURNS VALUES OF THE ELEMENTS OF THE
C       INVERSE OF THE MATRIX D SUB I,I+1.....
C
      REAL * 4 AL(100),AM(100),AR(100),PIMAT(100,100),TEM(100,100),
     1 B(100),X(100)
      REAL * 4 DINV(100,100)
      INTEGER * 4 IP(100),LIMU(100)
   10 FORMAT (/T10,'UPPER LIMIT OF THE DO LOOP IS LOWER THAN ITS LOWER L
     1IMIT.PROGRAM TERMINATED.I AND LIMU(I) ARE =',2I5//)
   20 FORMAT (/T10,'ALL ELEMENTS IN ROW NUMBER',I5,T45,'ARE ZEROS. PROGR
     1AM TERMINATED.'/)
   30 FORMAT (/T10,'ZERO PIVOT FOR COLUMN NUMBER',I5,T47,'. PROGRAM TERM
     1INATED.'/)
C
C       DECOMPOSE A MATRIX (GAUSSIAN ELIMINATION WITH PIVOTING )
C       IN L * U FORM. CHAPTERS 9 & 11 OF COMPUTER SOLUTION OF LINEAR
C       ALGEBRAIC SYSTEMS BY G. FORSYTHE AND C.B. MOLER,
C       PRENTICE - HALL, 1967..
C
      IW = 6
      NMX1 = NMX - 1
      DO 110 J = 1,NMX
      DO 105 I = 1,NMX
      TEM(I,J) = 0.0
  105 CONTINUE
  110 CONTINUE
      DO 115 I = 1,NMX
      IP(I) = I
      TEM(I,I) = AM(I)
  115 CONTINUE
      DO 120 I = 2,NMX
      I1 = I - 1
      TEM(I,I1) = AL(I)
```

```
120 CONTINUE
    DO 125 I = 1,NMX1
    I1 = I + 1
    TEM(I,I1) = AR(I)
125 CONTINUE
    X(1) = AMAX1(ABS(TEM(1,1)),ABS(TEM(1,2)))
    X(NMX) = AMAX1(ABS(TEM(NMX,NMX1)),ABS(TEM(NMX,NMX)))
    DO 130 I = 2,NMX1
    I1 = I - 1
    I2 = I + 1
    X(I) = AMAX1(ABS(TEM(I,I1)),ABS(TEM(I,I)))
    X(I) = AMAX1(X(I),ABS(TEM(I,I2)))
130 CONTINUE
    DO 140 I = 1,NMX
    IF ( X(I) .NE. 0.0 ) GO TO 135
    WRITE (IW,20) I
    CALL EXIT
135 X(I) = 1.0/X(I)
140 CONTINUE
    DO 180 K = 1,NMX1
    TEMA = 0.0
    K1 = K + 1
    DO 150 I = K,K1
    IS = IP(I)
    TEMB = TEM(IS,K) * X(IS)
    TEMB = ABS(TEMB)
    IF ( TEMB .LE. TEMA ) GO TO 150
    TEMA = TEMB
    IDX = I
150 CONTINUE
    IF ( TEMA .NE. 0.0) GO TO 155
    WRITE (IW,30) K
    CALL EXIT
155 CONTINUE
    IF ( IDX .EQ. K) GO TO 160
    J = IP(K)
    IP(K) = IP(IDX)
    IP(IDX) = J
160 CONTINUE
    KP = IP(K)
    TEMA = 1.0/TEM(KP,K)
    K2 = K + 2
    IF ( K2 .GT. NMX ) K2 = NMX
    DO 175 I = K1,K2
    IS = IP(I)
    TEM(IS,K) = TEM(IS,K) * TEMA
    K3 = K + 3
    IF ( K3 .GT. NMX ) K3 = NMX
    DO 170 J = K1,K3
    TEM(IS,J) = TEM(IS,J) - TEM(IS,K) * TEM(KP,J)
170 CONTINUE
175 CONTINUE
180 CONTINUE
    IS = IP(NMX)
    IF ( TEM(IS,NMX) .NE. 0.0 ) GO TO 190
```

```
      WRITE (IW,30) NMX
      CALL EXIT
  190 CONTINUE
      DO 210 I = 1,NMX
      IF ( IP(I) .GE. I ) GO TO 205
      LIMU(I) = IP(I) - 1
      GO TO 208
  205 LIMU(I) = I - 1
  208 CONTINUE
      IF ( LIMU(I) .LE. 0 ) LIMU(I) = 1
  210 CONTINUE
      DO 220 I = 1,NMX
      B(I) = 0.0
  220 CONTINUE
      DO 400 ISOL = 1,NMX
      IF ( ISOL .NE. 1 ) B(ISOL-1) = 0.0
      B(ISOL) = 1.0
C
C       SOLVE THE LINEAR SYSTEM OF EQUATIONS (A * X = B ) BY USING
C       THE L * U DECOMPOSITION OF THE A MATRIX...
C
C       COMPUTE U * X = (INVERSE OF L) * B = X TEMPORARY..
C       NOTE THAT THE L MATRIX IS A BIDIAGONAL ONE WITH ALL ELEMENTS
C        ALONG ITS MAIN DIAGONAL EQUAL TO UNITY...
C
C       COMPUTE U * X = (INVERSE OF L ) * B = X TEMPORARY..
C
      X(1) = B(IP(1))
      DO 260 I = 2,NMX
      IS = IP(I)
      I1 = LIMU(I)
      I2 = I - 1
      X(I) = B(IS)
      IF ( I2 - I1 ) 225,230,250
  225 WRITE (IW,10) I,LIMU(I)
      CALL EXIT
  230 X(I) = X(I) - TEM(IS,I1) * X(I1)
      GO TO 260
  250 CONTINUE
      DO 255 J = I1,I2
      X(I) = X(I) - TEM(IS,J) * X(J)
  255 CONTINUE
  260 CONTINUE
      IS = IP(NMX)
      X(NMX) = X(NMX)/TEM(IS,NMX)
C
C       COMPUTE X = (INVERSE OF U )* X TEMPORARY...
C
      II = NMX - 1
      IS = IP(II)
      X(II) = ( X(II) - TEM(IS,NMX)*X(NMX))/TEM(IS,II)
      DO 280 I = 3,NMX
      II = NMX + 1 - I
      IS = IP(II)
      I1 = II + 1
```

```
      I2 = I1 + 1
      X(II) = (X(II) - TEM(IS,I1)*X(I1) - TEM(IS,I2)*X(I2))/TEM(IS,II)
  280 CONTINUE
      DO 300 J = 1,NMX
      PIMAT(J,ISOL) = X(J)
  300 CONTINUE
  400 CONTINUE
C
C      PIMAT NOW CONTAINS INVERSE OF THE MATRIX S SUB I,I+1.....
C
C      RE-ARRANGE ROWS OF PIMAT TO GENERATE INVERSE OF THE MATRIX
C      D SUB I,I+1...
C
      NMX2 = NMX/2
      DO 440 I = 1,NMX2
      I2 = 2*I - 1
      DO 420 J = 1,NMX
      DINV(I,J) = PIMAT(I2,J)
  420 CONTINUE
  440 CONTINUE
      DO 480 I = 1,NMX2
      I1 = 2 * I
      I2 = NMX2 + I
      DO 460 J = 1,NMX
      DINV(I2,J) = PIMAT(I1,J)
  460 CONTINUE
  480 CONTINUE
C
C      COMPUTE THE MATRIX (-I + 2 * INVERSE OF S SUB I,I+1 * A).....
C
      DO 540 J = 1,NMX
      TEM(J,1) = 2.0 * PIMAT(J,2) * AL(2)
      DO 520 K = 2,NMX1
      K1 = K - 1
      K2 = K + 1
      TEM(J,K) = 2.0 * (PIMAT(J,K1) * AR(K1) + PIMAT(J,K2) * AL(K2))
  520 CONTINUE
      TEM(J,NMX) = 2.0 * PIMAT(J,NMX1) * AR(NMX1)
  540 CONTINUE
      DO 550 I = 1,NMX
      TEM(I,I) = -1.0 + TEM(I,I)
  550 CONTINUE
C
C      RE-ARRANGE BY ROWS AND THEN BY COLUMNS TO GENERATE PI MATRIX....
C
      DO 560 J = 1,NMX2
      J1 = J * 2 - 1
      DO 555 I = 1,NMX
      PIMAT(I,J) = TEM(I,J1)
  555 CONTINUE
  560 CONTINUE
      DO 570 J = 1,NMX2
      J1 = NMX2 + J
      J2 = J * 2
      DO 565 I = 1,NMX
```

```
      PIMAT(I,J1) = TEM(I,J2)                                           PITRX207
  565 CONTINUE                                                          PITRX208
  570 CONTINUE                                                          PITRX209
      DO 580 I = 1,NMX2                                                 PITRX210
      I1 = I * 2 - 1                                                    PITRX211
      DO 575 J = 1,NMX                                                  PITRX212
      TEM(I,J) = PIMAT(I1,J)                                            PITRX213
  575 CONTINUE                                                          PITRX214
  580 CONTINUE                                                          PITRX215
      DO 590 I = 1,NMX2                                                 PITRX216
      I1 = NMX2 + I                                                     PITRX217
      I2 = I * 2                                                        PITRX218
      DO 585 J = 1,NMX                                                  PITRX219
      TEM(I1,J) = PIMAT(I2,J)                                           PITRX220
  585 CONTINUE                                                          PITRX221
  590 CONTINUE                                                          PITRX222
      DO 600 I = 1,NMX                                                  PITRX223
      DO 595 J = 1,NMX                                                  PITRX224
      PIMAT(I,J) = TEM(I,J)                                             PITRX225
  595 CONTINUE                                                          PITRX226
  600 CONTINUE                                                          PITRX227
      RETURN                                                            PITRX228
      END                                                               PITRX229
      SUBROUTINE POLATE (YTAB,X,Y)                                      POLAT  1
C                                                                       POLAT  2
C      SUBROUTINE FOR OBTAINING A LINEARLY INTERPOLATED                 POLAT  3
C      VALUE (Y) OF A FUNCTION AT A POINT X, WHEN ITS TABULATED         POLAT  4
C      VALUES (YTAB) ARE AVAILABLE AT 0.01 INTERVAL IN X STARTING       POLAT  5
C      WITH X = 0.00....                                                POLAT  6
C                                                                       POLAT  7
      REAL * 4 YTAB(1)                                                  POLAT  8
      N = 100.0 * X + 1                                                 POLAT  9
      N1 = N + 1                                                        POLAT 10
      XN = 0.01 * (N-1)                                                 POLAT 11
      Y = YTAB(N) + (100.0 * (X - XN) * (YTAB(N1) - YTAB(N)))           POLAT 12
      RETURN                                                            POLAT 13
      END                                                               POLAT 14
      SUBROUTINE SLPTH (AMUO,DELS)                                      SLPTH  1
C                                                                       SLPTH  2
C      COMPUTATIONS OF THE LENGTH OF ONE KM VERTICAL PATHS IN A         SLPTH  3
C      SPHERICAL ATMOSPHERE ALONG VARIOUS DIRECTIONS, AND               SLPTH  4
C      AT VARIOUS POINTS IN THE ATMOSPHERE....                          SLPTH  5
C                                                                       SLPTH  6
      REAL * 4 DELS(32,10,32),H(33),AMUO(10),AMUOSQ(10),RDH(33)         SLPTH  7
      DATA H /70.0,60.0,50.0,45.0,40.0,35.0,30.0,25.0,24.0,23.0,22.0,   SLPTH  8
     1 21.0,20.0,19.0,18.0,17.0,16.0,15.0,14.0,13.0,12.0,11.0,10.0,     SLPTH  9
     2 9.0,8.0,7.0,6.0,5.0,4.0,3.0,2.0,1.0,0.0/                         SLPTH 10
      DATA RAD /6371.0/                                                 SLPTH 11
      DO 130 L = 1,32                                                   SLPTH 12
      RDH(L) = 1.0/(H(L) - H(L+1))                                      SLPTH 13
      DO 120 J = 1,10                                                   SLPTH 14
      DO 110 K = 1,32                                                   SLPTH 15
      DELS(K,J,L) = 0.0                                                 SLPTH 16
  110 CONTINUE                                                          SLPTH 17
  120 CONTINUE                                                          SLPTH 18
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```
  130 CONTINUE
      DO 140 J = 1,10
      AMUO(J) = -AMUO(J)
      AMUOSQ(J) = AMUO(J) * AMUO(J)
  140 CONTINUE
      RAD2 = 2.0 * RAD
      DO 200 KK = 1,32
      K = KK + 1
      DO 190 J = 1,10
      TEMX = (RAD + H(K)) * (RAD + H(K)) * AMUOSQ(J)
      TEMY = (RAD + H(K)) * AMUO(J)
      TEMA = TEMX + (H(1) - H(K)) * (RAD2 + H(K) + H(1))
      TEMA = SQRT(TEMA) - TEMY
      DO 180 L = 2,K
      L1 = L - 1
      TEMB = TEMX + (H(L) - H(K)) * (RAD2 + H(K) + H(L))
      TEMB = SQRT(TEMB) - TEMY
      DELS(L1,J,KK) = TEMA - TEMB
      TEMA = TEMB
  180 CONTINUE
  190 CONTINUE
  200 CONTINUE
      DO 203 K = 1,32
      DO 202 J = 1,10
      DO 201 L = 1,K
      DELS(L,J,K) = DELS(L,J,K) * RDH(L)
  201 CONTINUE
  202 CONTINUE
  203 CONTINUE
      RETURN
      END
      SUBROUTINE SOLISY (NCASE,A,AINV,TEM,X,B,IP,NMX,ITR,RESID,DELX)
C
C       NCASE = 1 : OBTAIN AN INVERSE OF MATRIX A IN LOCATION
C                     REPRESENTED BY AINV...
C
C       NCASE = 2 : SOLVE THE LINEAR SYSTEM OF EQUATIONS A * X = B WHERE
C                     A IS AN NMX BY NMX SQUARE MATRIX AND, X AND B
C                     ARE VECTORS WITH NMX ELEMENTS.
C
C       ITR (+) : NUMBER OF ITERATICNS REQUIRED TO OBTAIN THE DESIRED
C                 CONVERGENCE OF THE SOLUTION...
C       ITR (-) : ABSOLUTE VALUE OF ITR GIVES THE NUMBER OF DIGITS
C                 TO WHICH THE FIRST TWO SETS OF X AGREE. NEGATIVE VALUES
C                 OF ITR ARE RETURNED ONLY WHEN THE INPUT MATRIX
C                 IS TOO ILL-CONDITIONED TO ATTEMPT ANY CONVERGENCE..
C       ITR = 0 : ITERATIONS DID NOT CONVERGE....
C
      REAL * 4 A(100,100),AINV(100,100),TEM(100,100),B(100),X(100),
     1 RESID(100),DELX(100)
      INTEGER * 4 IP(100)
      REAL * 8 AUL,BUL
   20 FORMAT (/T10,'ALL ELEMENTS IN ROW NUMBER',I5,T45,'ARE ZEROS. PROGR
     1AM TERMINATED.'/)
   30 FORMAT (/T10,'ZERO PIVOT FOR COLUMN NUMBER',I5,T47,'. PROGRAM TERM
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     1INATED.'/)
  40 FORMAT (/T10,'A SOLUTION OF A*X=B SYSTEM GIVES A ZERO VALUE FOR AL
     1L COMPONENTS OF VECTOR X. PROGRAM TERMINATED.'/)
C
C       DECOMPOSE A MATRIX (GAUSSIAN ELIMINATION WITH PIVOTING )
C       IN L * U FORM. CHAPTERS 9 & 11 OF COMPUTER SOLUTION OF LINEAR
C       ALGEBRAIC SYSTEMS BY G. FORSYTHE AND C.B. MOLER,
C       PRENTICE - HALL, 1967..
C
      IW = 6
      DO 130 I = 1,NMX
      X(I) = 0.0
      IP(I) = I
      DO 120 J = 1,NMX
      TEM(I,J) = A(I,J)
      X(I) = AMAX1(X(I),ABS(TEM(I,J)))
  120 CONTINUE
      IF ( X(I) .NE. 0.0 ) GO TO 125
      WRITE (IW,20) I
      CALL EXIT
  125 X(I) = 1.0/X(I)
  130 CONTINUE
      NMX1 = NMX - 1
      DO 180 K = 1,NMX1
      TEMA = 0.0
      DO 150 I = K,NMX
      IS = IP(I)
      TEMB = TEM(IS,K) * X(IS)
      TEMB = ABS(TEMB)
      IF ( TEMB .LE. TEMA ) GO TO 150
      TEMA = TEMB
      IDX = I
  150 CONTINUE
      IF ( TEMA .NE. 0.0) GO TO 155
      WRITE (IW,30) K
      CALL EXIT
  155 CONTINUE
      IF ( IDX .EQ. K) GO TO 160
      J = IP(K)
      IP(K) = IP(IDX)
      IP(IDX) = J
  160 CONTINUE
      KP = IP(K)
      TEMA = 1.0/TEM(KP,K)
      KP1 = K + 1
      DO 175 I = KP1,NMX
      IS = IP(I)
      TEM(IS,K) = TEM(IS,K) * TEMA
      DO 170 J = KP1,NMX
      TEM(IS,J) = TEM(IS,J) - TEM(IS,K) * TEM(KP,J)
  170 CONTINUE
  175 CONTINUE
  180 CONTINUE
      IS = IP(NMX)
      IF ( TEM(IS,NMX) .NE. 0.0 ) GO TO 190
```

```
      WRITE (IW,30) NMX
      CALL EXIT
  190 CONTINUE
      IF ( NCASE .EQ. 1 ) GO TO 200
      ISOL = NMX
      GO TO 240
  200 CONTINUE
      DO 220 I = 1,NMX
      B(I) = 0.0
  220 CONTINUE
      DO 1000 ISOL = 1,NMX
      IF ( ISOL .NE. 1 ) B(ISOL-1) = 0.0
      B(ISOL) = 1.0
  240 CONTINUE
      CALL SOLVE (TEM,X,B,IP,NMX)
C
C      IMPROVE THE SOLUTION X BY FOLLOWING THE PROCEDURE OUTLINED
C      IN CHAPTER 13 OF FORSYTHE AND MOLER..
C
C      THE QUANTITIES MAXITR, IDIG, AND TEMC ARE MACHINE DEPENDENT.
C      THEIR VALUES AS GIVEN BELOW ARE FOR SINGLE PRECISION WORK ON
C      SYSTEMS 360 AND 370...
C
      MAXITR = 15
      IDIG = 7
      TEMC = 1.0E-06
      TEMA = 0.0
      DO 250 I = 1,NMX
      TEMA = AMAX1(TEMA,ABS(X(I)))
  250 CONTINUE
      IF ( TEMA .NE. 0.0) GO TO 260
      WRITE (IW,40)
      CALL EXIT
  260 CONTINUE
      DO 400 ITR =1,MAXITR
      DO 300 I = 1,NMX
      AUL = B(I)
      DO 290 J = 1,NMX
      BUL = X(J)
      AUL = AUL - A(I,J) * BUL
  290 CONTINUE
      RESID(I) = AUL
  300 CONTINUE
      CALL SOLVE (TEM,DELX,RESID,IP,NMX)
      TEMB = 0.0
      DO 320 I = 1,NMX
      TEMB = AMAX1(TEMB,ABS(DELX(I)))
      X(I) = X(I) + DELX(I)
  320 CONTINUE
      IF ( ITR .NE. 1 ) GO TO 370
      II = -ALOG10(ABS(TEMB/TEMA))
      IDIG = MINO(II,IDIG)
      IF ( IDIG .LE. 3 ) GO TO 410
  370 CONTINUE
      IF ( TEMB .LE. TEMA*TEMC) GO TO 450
```

```
  400 CONTINUE
      GO TO 420
  410 ITR = -IDIG
      RETURN
  420 ITR = 0
      RETURN
  450 CONTINUE
      IF ( NCASE .EQ. 2 ) RETURN
      DO 480 J = 1,NMX
      AINV(J,ISOL) = X(J)
  480 CONTINUE
      IF ( ISOL .EQ. 1 ) JVD = ITR
      IF ( ISOL .GT. 1 ) JVD = MAXO(JVD,ITR)
 1000 CONTINUE
      ITR = JVD
      RETURN
      END
      SUBROUTINE SOLVE (TEM,X,B,IP,NMX)
C
C      THIS SUBROUTINE IS CALLED BY THE SUBROUTINE SOLISY. L * U
C      MATRIX IS IN THE LOCATION TEM..
C
C      SOLVE THE LINEAR SYSTEM OF EQUATIONS (A * X = B ) BY USING
C      THE L * U DECOMPOSITION OF A MATRIX OBTAINED EARLIER..
C
C      COMPUTE U * X = (INVERSE OF L ) * B = X TEMPORARY..
C
      REAL * 4 TEM(100,100),X(100),B(100)
      INTEGER * 4 IP(100)
      X(1) = B(IP(1))
      DO 260 I = 2,NMX
      IS = IP(I)
      IM = I - 1
      X(I) = B(IS)
      DO 250 J = 1,IM
      X(I) = X(I) - TEM(IS,J) * X(J)
  250 CONTINUE
  260 CONTINUE
      IS = IP(NMX)
      X(NMX) = X(NMX)/TEM(IS,NMX)
C
C      COMPUTE X = (INVERSE OF U ) * X TEMPORARY..
C
      DO 280 I = 2,NMX
      II = NMX + 1 - I
      IS = IP(II)
      IP1 = II + 1
      DO 270 J = IP1,NMX
      X(II) = X(II) - TEM(IS,J) * X(J)
  270 CONTINUE
      X(II) = X(II)/TEM(IS,II)
  280 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTA ( OMEGR,COFAR,OMEGST,COFAS,OMEGTP,COFAT,
```

```
     1 MXNLYR,NTR,DTAUH,ATEN,FNYN,CAPLAM,CAPLX,CAPLY)
C
C       SUBROUTINE FOR COMPUTING CAPITAL LAMDA SUB K OF TAU SUB L
C       AND OTHER RELATED QUANTITIES....
C
      REAL * 4 OMEGR(300),COFAR(3),OMEGST(300),COFAS(300),
     1 OMEGTP(300),COFAT(300),DTAUH(300),ATEN(301,10),FNYN(300,10),
     2 CAPLAM(100,300),CAPLX(100,300),CAPLY(100,300,11)
      DO 150 L = 1,MXNLYR
      DO 110 I = 1,3
      CAPLAM(I,L) = OMEGR(L) * COFAR(I) + OMEGST(L) * COFAS(I) +
     1 OMEGTP(L) * COFAT(I)
  110 CONTINUE
      DO 130 I = 4,NTR
      CAPLAM(I,L) = OMEGST(L) * COFAS(I) + OMEGTP(L) * COFAT(I)
  130 CONTINUE
  150 CONTINUE
      DO 200 I = 1,NTR
      TEMA = 1.0/(2*I - 1)
      TEMB = 0.5 * TEMA
      DO 190 L = 1,MXNLYR
      L1 = L + 1
      CAPLX(I,L) = CAPLAM(I,L) * TEMA * DTAUH(L) - DTAUH(L)
      DO 170 N = 1,10
      CAPLY(I,L,N) = DTAUH(L) * (ATEN(L,N) + ATEN(L1,N)) *
     1 CAPLAM(I,L) * FNYN(I,N) * TEMB
  170 CONTINUE
  190 CONTINUE
  200 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTB ( AVECT,FMAT,GMAT,NTR,NTR2)
C
C       SUBROUTINE FOR INITIALIZING F SUB 1 MATRIX, AND A VECTORS...
C
      REAL * 4 AVECT(100,11),FMAT(100,50),GMAT(50,50)
      DO 150 J = 1,11
      DO 130 I = 1,NTR
      AVECT(I,J) = 0.0
  130 CONTINUE
  150 CONTINUE
      DO 200 J = 1,NTR2
      DO 170 I = 1,NTR2
      FMAT(I,J) = 0.0
      FMAT(NTR2+I,J) = -GMAT(I,J)
  170 CONTINUE
  200 CONTINUE
      DO 250 I = 1,NTR2
      FMAT(I,I) = 1.0
  250 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTC (A,PIMAT,FMAT,DINV,CAPLY,AVECT,NTR,NTR2,L)
C
C       SUBROUTINE FOR COMPUTING F SUB J MATRIXES, AND A SUB J VECTORS.
```

```
C
      REAL * 4 A(300),PIMAT(100,100),FMAT(100,50),DINV(100,100),
     1 CAPLY(100,300,11),AVECT(100,11)
      DO 200 J = 1,NTR2
      DO 150 I = 1,NTR
      A(I) = 0.0
      DO 120 K = 1,NTR
      A(I) = A(I) + PIMAT(I,K) * FMAT(K,J)
  120 CONTINUE
  150 CONTINUE
      DO 180 I = 1,NTR
      FMAT(I,J) = A(I)
  180 CONTINUE
  200 CONTINUE
      DO 400 N = 1,11
      DO 360 I = 1,NTR
      A(I) = 0.0
      DO 350 J = 1,NTR
      A(I) = A(I) + DINV(I,J) * CAPLY(J,L,N)  +
     1 PIMAT(I,J) * AVECT(J,N)
  350 CONTINUE
  360 CONTINUE
      DO 370 I = 1,NTR
      AVECT(I,N) = A(I)
  370 CONTINUE
  400 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTD (CINV,FMAT,NTR2)
      REAL * 4 CINV(100,100),FMAT(100,50)
      DO 200 J = 1,NTR2
      DO 150 I = 1,NTR2
      CINV(I,J) = FMAT(I,J)
  150 CONTINUE
  200 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTE ( TMAT,CIMAT,FMAT,UMAT,NTR2)
C
C       SUBROUTINE FOR COMPUTING THE  U AND T MATRIXES....
C
      REAL * 4 TMAT(50,50),CIMAT(100,100),FMAT(100,50),UMAT(50,50)
      DO 200 I = 1,NTR2
      I1 = NTR2 + I
      DO 150 J = 1,NTR2
      TMAT(I,J) = CIMAT(I,J)
      TEMA = 0.0
      DO 130 K = 1,NTR2
      TEMA = TEMA + FMAT(I1,K) * CIMAT(K,J)
  130 CONTINUE
      UMAT(I,J) = TEMA
  150 CONTINUE
  200 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SUBSTF (FMAT,UMAT,NTR2)
C
C      SUBROUTINE FOR INITIALIZING F SUB J MATRIX AFTER PERFORMING
C      A STABILIZING TRANSFORMATION.....
C
      REAL * 4 FMAT(100,50),UMAT(50,50)
      DO 200 J = 1,NTR2
      DO 150 I = 1,NTR2
      FMAT(I,J) = 0.0
      FMAT(NTR2+I,J) = UMAT(I,J)
  150 CONTINUE
  200 CONTINUE
      DO 250 I = 1,NTR2
      FMAT(I,I) = 1.0
  250 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTG (TVECT,AVECT,UMAT,UVECT,NTR,NTR2,NTR21)
C
C      SUBROUTINE FOR SETTING UP U AND T VECTORS AFTER
C      PERFORMING A STABILIZING TRANSFORMATION....
C
      REAL * 4 TVECT(50,11),AVECT(100,11),UMAT(50,50),UVECT(50,11)
      DO 300 N = 1,11
      DO 150 I = 1,NTR2
      TVECT(I,N) = AVECT(I,N)
      TEMA = -AVECT(NTR2+I,N)
      DO 130 J = 1,NTR2
      TEMA = TEMA + UMAT(I,J) * AVECT(J,N)
  130 CONTINUE
      UVECT(I,N) = TEMA
  150 CONTINUE
      DO 230 I = 1,NTR2
      AVECT(I,N) = 0.0
  230 CONTINUE
      DO 250 I = NTR21,NTR
      AVECT(I,N) = -UVECT(I-NTR2,N)
  250 CONTINUE
  300 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTH (DINV,UMAT,GMAT,NTR2)
      REAL * 4 DINV(100,100),UMAT(50,50),GMAT(50,50)
      DO 200 J = 1,NTR2
      DO 150 I = 1,NTR2
      DINV(I,J) = UMAT(I,J) - GMAT(I,J)
  150 CONTINUE
  200 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTI (N,VECL2,GMAT,NTR2)
      REAL * 4 VECL2(100,11),GMAT(50,50)
      DO 200 I = 1,NTR2
      TEMA = 0.0
      DO 150 J = 1,NTR2
```

```
      TEMA = TEMA + GMAT(I,J) * VECL2(J,N)
  150 CONTINUE
      VECL2(NTR2+I,N) = TEMA
  200 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTJ (ISW,K1,NTR2,VECL1,VECL2,TVECT,AVECT,UVECT,
     1 TMAT,UMAT,GMAT)
C
C       SUBROUTINE FOR COMPUTING L SUB K VECTORS...
C
      REAL * 4 VECL1(100,11),VECL2(100,11),TVECT(50,11),AVECT(100,11),
     1 UVECT(50,11),TMAT(50,50),UMAT(50,50),GMAT(50,50)
      INTEGER * 4 ISW(11)
      DO 700 N = 1,11
      IF ( ISW(N) .NE. 0 ) GO TO 700
      DO 630 I = 1,NTR2
      TEMA = 0.0
      DO 620 J = 1,NTR2
      TEMA = TEMA + TMAT(I,J) * (VECL2(J,N) - TVECT(J,N))
  620 CONTINUE
      VECL1(I,N) = TEMA
      AVECT(I,N) = TEMA
  630 CONTINUE
      IF ( K1 .EQ. 0 ) GO TO 665
      DO 650 I = 1,NTR2
      TEMA = -UVECT(I,N)
      DO 640 J = 1,NTR2
      TEMA = TEMA + UMAT(I,J) * VECL1(J,N)
  640 CONTINUE
      AVECT(NTR2+I,N) = TEMA
  650 CONTINUE
      GO TO 700
  665 CONTINUE
      DO 680 I = 1,NTR2
      TEMA = 0.0
      DO 670 J = 1,NTR2
      TEMA = TEMA - GMAT(I,J) * VECL1(J,N)
  670 CONTINUE
      AVECT(NTR2+I,N) = TEMA
  680 CONTINUE
  700 CONTINUE
      RETURN
      END
      SUBROUTINE SUBSTK (AMOMT,AVECT,NTR,NTR2)
C
C       SUBROUTINE FOR RE-ARRANGING LEGENDRE MOMENTS OF THE
C       INTENSITY COMPONENT.....
C
      REAL * 4 AMOMT(100,11),AVECT(100,11)
      DO 200 N = 1,11
      DO 140 I = 1,NTR2
      AMOMT(2*I-1,N) = AVECT(I,N)
  140 CONTINUE
      NTR21 = NTR2 + 1
```

```
      DO 180 I = NTR21,NTR                                              SUBTK 12
      AMOMT(2*I-NTR,N) = AVECT(I,N)                                     SUBTK 13
  180 CONTINUE                                                          SUBTK 14
  200 CONTINUE                                                          SUBTK 15
      RETURN                                                            SUBTK 16
      END                                                               SUBTK 17
      SUBROUTINE SUBSTL (B,DINV,CAPLY,PIMAT,AVECT,NTR,L1)               SUBTL  1
      REAL * 4 B(300),DINV(100,100),CAPLY(100,300,11),PIMAT(100,100),   SUBTL  2
     1 AVECT(100,11)                                                    SUBTL  3
      DO 780 N = 1,11                                                   SUBTL  4
      DO 770 I = 1,NTR                                                  SUBTL  5
      B(I) = 0.0                                                        SUBTL  6
      DO 760 J = 1,NTR                                                  SUBTL  7
      B(I) = B(I) + DINV(I,J) * CAPLY(J,L1,N) +  PIMAT(I,J) * AVECT(J,N)SUBTL  8
  760 CONTINUE                                                          SUBTL  9
  770 CONTINUE                                                          SUBTL 10
      DO 775 I = 1,NTR                                                  SUBTL 11
      AVECT(I,N) = B(I)                                                 SUBTL 12
  775 CONTINUE                                                          SUBTL 13
  780 CONTINUE                                                          SUBTL 14
      RETURN                                                            SUBTL 15
      END                                                               SUBTL 16
      SUBROUTINE SUBSTM(CAPLAM,BTEN,AMOMT,BMOMT,FNYP,DTAUH,EIN,NTR,L,L1)SUBTM  1
C                                                                       SUBTM  2
C       SUBROUTINE FOR COMPUTING MULTIPLE-SCATTERING CONTRIBUTION       SUBTM  3
C       TO THE SCATTERED RADIATION.....                                 SUBTM  4
C                                                                       SUBTM  5
      REAL * 4 CAPLAM(100,300),BTEN(301,18),AMOMT(100,11),BMOMT(100,11),SUBTM  6
     1 FNYP(300,18),DTAUH(300),EIN(18,11)                               SUBTM  7
      TEMB = 0.5 * DTAUH(L1)                                            SUBTM  8
      DO 798 N = 1,11                                                   SUBTM  9
      DO 792 J = 1,18                                                   SUBTM 10
      TEMA = 0.0                                                        SUBTM 11
      DO 785 I = 1,NTR                                                  SUBTM 12
      TEMA = TEMA + CAPLAM(I,L1) * (BTEN(L1,J) * AMOMT(I,N) +           SUBTM 13
     1 BTEN(L,J) * BMOMT(I,N)) * FNYP(I,J) * TEMB                       SUBTM 14
  785 CONTINUE                                                          SUBTM 15
      EIN(J,N) = EIN(J,N) + TEMA                                        SUBTM 16
  792 CONTINUE                                                          SUBTM 17
      DO 795 I = 1,NTR                                                  SUBTM 18
      AMOMT(I,N) = BMOMT(I,N)                                           SUBTM 19
  795 CONTINUE                                                          SUBTM 20
  798 CONTINUE                                                          SUBTM 21
      RETURN                                                            SUBTM 22
      END                                                               SUBTM 23
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6.3 <u>Program SITBB</u>: (See page 93.)

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C
C     PROGRAM FOR COMPUTING THE O-TH FOURIER COMPONENT OF THE
C     INTENSITY OF THE SCATTERED RADIATION EMERGING AT THE TOP
C     OF A NONHOMOGENEOUS ATMOSPHERIC MODEL WITH ARBITRARY VERTICAL
C     DISTRIBUTIONS OF OZONE AND STRATOSPHERIC AS WELL AS TROPOSPHERIC
C     AEROSOLS, AND RESTING ON A LAMBERT GROUND.....
C
C     THIS PARTICULAR PROGRAM IS BASED ON THE USE OF THE SPHERICAL
C     HARMONICS METHOD IN CONJUNCTION WITH PERFORMING OF THE
C     STABILIZING TRANSFORMATIONS AT ANYWHERE FROM TWO TO
C     ONE HUNDRED AND ONE CONDITIONING POINTS....
C
C     IN THIS PROGRAM, WE FOLLOW CHANDRASEKHAR'S CONVENTION ,I.E.,
C     DOWNWARD DIRECTION IS REPRESENTED BY -MU......
C
      DATA XBLNK /'    '/
      REAL * 4 GTH(32),PRTH(32),OZOTH(32),STDUST(32),TPDUST(32)
      REAL * 8 DATE,HOUR
      REAL * 4 THETO(10),AMUO(10),A(300),B(300),C(300),D(300),TAU(301),
     1 TITB(14),COFAS(300),COFAT(300),DTAU(300),THETA(18),AMU(18)
      REAL * 4 AL(100),AR(100),GMAT(50,50),ATEN(301,10),DELS(32,10,32)
      REAL * 4 UMAT(50,50),TMAT(50,50),TVECT(50,11),UVECT(50,11)
      REAL * 4 FMAT(100,50),AVECT(100,11),BTEN(301,18)
      REAL * 4 PIMAT(100,100),TEM(100,100),DINV(100,100)
      REAL * 4 CINV(100,100),CIMAT(100,100)
      REAL * 4 VECL1(100,11),VECL2(100,11)
      REAL * 4 FNYP(300,18),FNYN(300,10),EIN(18,11),COFAR(3)
      REAL * 4 OMEGR(300),OMEGST(300),OMEGTP(300),DTAUH(300),AJVD(501),
     1 CAPLX(100,300),BREKA(100,50),BREKB(100,50)
      REAL * 4 BREKC(100,50),BREKD(100,50),FXS(301,11),FXD(301,11),
     1 FXU(301,11),FXN(301,11),CAPLY(100,300,11)
      REAL * 4 AMOMT(100,11),BMOMT(100,11),EIC(18,10,6),TIC(18,10,6),
     1 SSBERR(6),CAPLAM(100,300)
      EQUIVALENCE (BREKA(1,1),PIMAT(1,1)),(BREKB(1,1),PIMAT(1,51))
      EQUIVALENCE (BREKC(1,1),DINV(1,1)),(BREKD(1,1),DINV(1,51))
      DATA COFAR /1.0,0.0,0.5/
      INTEGER * 4 IP(100),LIMU(100),ISW(11),ICPOS(101),ICHCK(300)
      INTEGER * 4 INEW(33),IPITE(300)
    4 FORMAT (//T10,'PROGRAM TERMINATED AS THE INPUT MODEL CONTAINS
     1 MORE THAN 32 BASIC LAYERS. NBLYR = ',I5//T10,'OR NMOD IS NOT SET.
     2 NMOD = ',I5//)
    5 FORMAT (/T10,'PROGRAM TERMINATED AS THE NUMBER OF CONDITIONING POI
     1NTS IS OUTSIDE THE RANGE OF THE DIMENSION STATEMENTS.'//T20,
     2 ' INPUT PARAMETER NUMCON =',I5/)
    6 FORMAT (//T10,'PROGRAM TERMINATED AS THE AEROSOL MODEL REQUIRES
     1 MORE THAN 300 LEGENDRE COEFFICIENTS. NMX = ',I5//)
   10 FORMAT (1H1)
   12 FORMAT (2I10)
   15 FORMAT (I5,0P2F10.2,0PF10.5,1P2E11.2)
   17 FORMAT (2F10.5)
   19 FORMAT (I5,3F10.4)
   21 FORMAT (0P3F10.5,I5,1P2E15.5,3A4)
   23 FORMAT (1P5E13.5,I5)
   24 FORMAT (//T10,'PROGRAM TERMINATED AS WAVELENGTHS ON THE MAIN CARD,
     1 AND ON THE COEFF CARDS ARE UNEQUAL.'//T10,'ALDA AND BLDA =',
```

```
  2 2F10.5//)                                                           SITBB 56
25 FORMAT (//T10,'PROGRAM TERMINATED AS THE LEGENDRE COEFFICIENT CARDSITBB 57
  1S APE NOT IN ORDER FOR THE STRATOSPHERIC AEROSOL CASE. LL AND LM ASITBB 58
  2RE RESPECTIVELY = ',2I5//)                                           SITBB 59
26 FORMAT (//T10,'PROGRAM TERMINATED AS THE LEGENDRE COEFFICIENT CARDSITBB 60
  1S ARE NOT IN ORDER FOR THE TROPOSPHERIC AEROSOL CASE. LL AND LM    SITBB 61
  2 ARE RESPECTIVELY = ',2I5//)                                         SITBB 62
28 FORMAT (1H1/T6,'LAYER',T22,'GEOMETRIC',T43,'PRESSURE',T66,'OZONE',SITBB 63
  1 T78,'STRATOSPHERIC',T99,'TROPOSPHERIC'/T5,'NUMBER',                SITBB 64
  2 T22,'THICKNESS',T42,'THICKNESS',T65,'AMOUNT',T79,'DUST CONTENT',  SITBB 65
  3 T99,'DUST CONTENT'//)                                               SITBB 66
30 FORMAT (I10,0P2F20.2,0PF20.5,1P2E20.2)                               SITBB 67
32 FORMAT (////T30,'ATMOSPHERIC MODEL NUMBER : ',I5///T10,              SITBB 68
  1 'SURFACE PRESSURE (MB) : ',F10.2,T55,'TOTAL OZONE AMOUNT (ATM-CM)SITBB 69
  2 : ',F10.3////T40,'D U S T     D A T A'///T9,'TYPE OF',             SITBB 70
  3 T24,'SIZE DISTRIBUTION',T48,'PART OF REFRACTIVE INDEX',            SITBB 71
  4 T86,'TOTAL'/T8,'AEROSOLS',T30,'FUNCTION',T52,'REAL',                SITBB 72
  5 T62,'IMAGINARY',T85,'AMOUNT'/)                                      SITBB 73
34 FORMAT (/T4,'TROPOSPHERIC',9X,3A4,4X,0P2F15.3,1P1E20.2)              SITBB 74
36 FORMAT (/T4,'STRATOSPHERIC',8X,3A4,4X,0P2F15.3,1P1E20.2)             SITBB 75
38 FORMAT (1H1/T10,'LEGENDRE COEFFICIENTS REPRESENTING PHASE FUNCTIONSITBB 76
  1 FOR THE STRATOSPHERIC AEROSOL AT WAVELENGTH OF',F10.5//T4,'L',    SITBB 77
  2 T13,'L',T25,'L+1',T37,'L+2',T49,'L+3',T61,'L+4',T73,'L+5',        SITBB 78
  3 T85,'L+6',T97,'L+7',T109,'L+8',T121,'L+9'/)                        SITBB 79
40 FORMAT (I5,1P10E12.4)                                                SITBB 80
42 FORMAT (1H1/T10,'LEGENDRE COEFFICIENTS REPRESENTING PHASE FUNCTIONSITBB 81
  1 FOR THE TROPOSPHERIC AEROSOL AT WAVELENGTH OF',F10.5//T4,'L',     SITBB 82
  2 T13,'L',T25,'L+1',T37,'L+2',T49,'L+3',T61,'L+4',T73,'L+5',        SITBB 83
  3 T85,'L+6',T97,'L+7',T109,'L+8',T121,'L+9'/)                        SITBB 84
44 FORMAT (1H1/T20,'VARIOUS NORMAL OPTICAL THICKNESSES OF THE ENTIRE SITBB 85
  1 ATMOSPHERIC MODEL : ',I5//T20,'FOR THE INCIDENT RADIATION OF      SITBB 86
  2 WAVELENGTH : ',F10.5////                                            SITBB 87
  3 T30,'RAYLEIGH SCATTERING                : ',F10.5//               SITBB 88
  4 T30,'OZONE ABSORPTION                   : ',F10.5//               SITBB 89
  5 T30,'STRATOSPHERIC AEROSOL SCATTERING : ',F10.5//                 SITBB 90
  6 T30,'STRATOSPHERIC AEROSOL ABSORPTION : ',F10.5//                 SITBB 91
  7 T30,'TROPOSPHERIC AEROSOL SCATTERING  : ',F10.5//                 SITBB 92
  8 T30,'TROPOSPHERIC AEROSOL ABSORPTION  : ',F10.5//                 SITBB 93
  9 T30,'TOTAL                              : ',F10.5)                SITBB 94
45 FORMAT (//T10,'PROGRAM TERMINATED AS TOTAL NORMAL OPTICAL THICKNESSITBB 95
  1S OF THE MODEL IS GREATER THAN 5.0. IT IS = ',F10.5//)             SITBB 96
47 FORMAT (//T10,'PROGRAM TERMINATED AS THE MODEL HAS TO BE DIVIDED  SITBB 97
  1 INTO MORE THAN 300 LAYERS.'//)                                      SITBB 98
49 FORMAT (/T10,'THIS SET OF COMPUTATIONS IS DONE WITH',I10,T65,       SITBB 99
  1 'NUMBER OF TERMS.'//)                                               SITBB100
51 FORMAT (/T10,'CONDITIONING POINT',I5,T40,'IS AT THE OPTICAL DEPTH'SITBB101
  1 ,F10.5,T80,' GIVEN BY THE LEVEL NUMBER',I5)                         SITBB102
53 FORMAT (/T10,'THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER', SITBB103
  1 I5,T70,'ITERATIONS FOR THE CONDITIONING POINT NUMBER',I5)          SITBB104
55 FORMAT (/T10,'LINEAR SYSTEM SOLVED FOR THETA SUB ZERO = ',F10.2,   SITBB105
  1 T70,'AFTER',I5,T85,'NUMBER OF ITERATIONS.')                         SITBB106
57 FORMAT (/T10,'LINEAR SYSTEM SOLVED FOR THE ISOTROPIC CASE',         SITBB107
  1 T70,'AFTER',I5,T85,'NUMBER OF ITERATIONS.')                         SITBB108
61 FORMAT (///T15,'MODEL : ',I5,T40,'WAVELENGTH : ',F10.4,              SITBB109
  1 T85,'THETA SUB ZERO : ' ,F10.2/)                                    SITBB110
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   63 FORMAT (///T15,'MODEL : ',I5,T40,'WAVELENGTH : ',F10.4,
     1 T85,'ISOTROPIC GROUND ILLUMINATION FROM BELOW.'/)
   65 FORMAT (/T2,'LAY.',T13,'DIRECT',T27,'DIFFUSE',T41,'DIFFUSE',
     1 T56,'NET',T68,'LAY.',T77,'DIRECT',T90,'DIFFUSE',T104,'DIFFUSE',
     2 T119,'NET'/T2,'NUM.',T13,'FLUX',T27,'DOWNWARD',T41,'UPWARD',
     3 T56,'FLUX',T68,'NUM.',T77,'FLUX',T90,'DOWNWARD',T104,'UPWARD',
     4 T119,'FLUX'/)
   67 FORMAT (I5,1P4E14.4,4X,I5,1P4E14.4)
   69 FORMAT (I5,1P4E14.4)
   71 FORMAT (//T10,'SBAR = ',F10.5)
   73 FORMAT (1H1/T25,'MODEL NUMBER : ',I5,T75,'WAVELENGTH : ',
     1 F10.4//)
   75 FORMAT (T16,'0-TH FOURIER COMPONENT OF INTENSITY OF THE RADIATION
     1 EMERGENT AT THE TOP ( R = 0.0 ) FOR THETA SUB ZERO = '//T2,
     2 'THETA',T10,'AMU',10F11.2//)
   77 FORMAT (0PF5.1,0PF7.3,1P10E11.3)
   79 FORMAT (///T22,'CONTRIBUTION ( MULTIPLIED BY (1-R*SBAR)/R) DUE TO
     1 ISOTROPIC ILLUMINATION FROM BELOW.'//)
   95 FORMAT (/T5,' MODEL : ',I5,T30,'WAVELENGTH : ',F10.4,
     1 //T5,'VIRTUAL AND REAL TIME IN SECS. = ',2F10.2/)
C
C       FILE 11 : U MATRIX...
C       FILE 12 : T MATRIX...
C       FILE 13 : T VECTOR...
C       FILE 14 : U VECTOR...
C       FILE 15 : INTEGRALS REQUIRED FOR THE GROUND REFLECTION PART...
C       FILE 16 : OUTPUT OF I SUB ZERO AT THE TOP FOR 18 MUS AND 6 LAMDAS
C                 AND OTHER RELATED INFORMATION FOR A LFUTURE USE...
C       FILE 17 : PI AND DINV MATRIXES FOR ALL BASIC LAYERS...
C
      DEFINE FILE 11 (101,10000,L,IPA)
      DEFINE FILE 12 (101,10000,L,IPB)
      DEFINE FILE 13 (101,2200,L,IPC)
      DEFINE FILE 14 (101,2200,L,IPD)
      DEFINE FILE 15 (101,2004,L,IPE)
      DEFINE FILE 16 (200,8720,L,IPF)
      DEFINE FILE 17 (128,20000,L,IPG)
      IR = 1
      IW = 8
C
C       READ IN AND PRINT OUT ATMOSPHERIC PARAMETERS...
C
      READ (IR,12) NMOD,NBLYR
      IF ( NBLYR .LE. 32 .AND. NMOD .GT. 0 ) GO TO 101
      WRITE (IW,4) NBLYR,NMOD
      GO TO 1000
  101 READ (IR,15) (II,GTH(I),PRTH(I),OZOTH(I),STDUST(I),TPDUST(I),I=1,
     1 NBLYR)
      READ (IR,17) TEMA,TEMB
      DO 102 I = 1,NBLYR
      STDUST(I) = TEMA * STDUST(I)
      TPDUST(I) = TEMB * TPDUST(I)
  102 CONTINUE
      TITB(1) = 0.0
      TITB(2) = 0.0
```

```
      TITB(3) = 0.0
      TITB(4) = 0.0
      DO 104 I = 1,NBLYR
      TITB(1) = TITB(1) + PRTH(I)
      TITB(2) = TITB(2) + OZOTH(I)
      TITB(3) = TITB(3) + STDUST(I)
      TITB(4) = TITB(4) + TPDUST(I)
  104 CONTINUE
      WRITE (IW,28)
      WRITE (IW,30) (I,GTH(I),PRTH(I),OZOTH(I),STDUST(I),TPDUST(I),
     1 I = 1,NBLYR)
C
C      COMPUTE MODEL - INDEPENDENT QUANTITIES BY CALLING
C      VARIOUS SUBROUTINES....
C
      CALL LEGFUN (THETO,AMUO,FNYN,THETA,AMU,FNYP)
      CALL BCMAT (GMAT,AL,AR)
      CALL SLPTH (AMUC,DELS)
C
C      READ IN AND PRINT OUT OPTICAL PARAMETERS FOR THE INPUT LAMDA...
C
  108 CONTINUE
      CALL TIMDAT (DATE,HOUR,ITVB,ITRB)
      READ (IR,19,END=1000) ILDA,ALDA,TAUBSR,OZABS
      IF ( TITB(3) .GT. 0.0 ) GO TO 110
      TITB(5) = 1.0
      TITB(6) = 0.0
      TITB(9) = XBLNK
      TITB(10) = XBLNK
      TITB(11) = XBLNK
      NMXST = 0
      BSCAST = 0.0
      BABSST = 0.0
      DO 109 I = 1,300
      COFAS(I) = 0.0
  109 CONTINUE
      GO TO 118
  110 CONTINUE
      READ (IR,21) BLDA,TITB(5),TITB(6),NMXST,BSCAST,BABSST,TITB(9),
     1 TITB(10),TITB(11)
      IF ( NMXST .LE. 300 ) GO TO 111
      WRITE (IW,6) NMXST
      GO TO 1000
  111 IF ( ABS(ALDA - BLDA) .LE. 0.001 ) GO TO 112
      WRITE (IW,24) ALDA,BLDA
      GO TO 1000
  112 LL = 1
      DO 115 L = 1,NMXST,5
      READ (IR,23) COFAS(L),COFAS(L+1),COFAS(L+2),COFAS(L+3),
     1 COFAS(L+4),LM
      IF ( LL .EQ. LM ) GO TO 113
      WRITE (IW,25) LL,LM
      GO TO 1000
  113 LL = LL + 5
  115 CONTINUE
```

```
  118 IF ( TITB(4) .GT. 0.0 ) GO TO 120
      TITB(7) = 1.0
      TITB(8) = 0.0
      TITB(12) = XBLNK
      TITB(13) = XBLNK
      TITB(14) = XBLNK
      NMXTP = 0
      BSCATP = 0.0
      BABSTP = 0.0
      DO 119 I = 1,300
      COFAT(I) = 0.0
  119 CONTINUE
      GO TO 130
  120 CONTINUE
      READ (IR,21) BLDA,TITB(7),TITB(8),NMXTP,BSCATP,BABSTP,TITB(12),
     1 TITB(13),TITB(14)
      IF ( NMXTP .LE. 300 ) GO TO 121
      WRITE (IW,6) NMXTP
      GO TO 1000
  121 IF ( ABS(ALDA - BLDA) .LE. 0.001 ) GO TO 122
      WRITE (IW,24) ALDA,BLDA
      GO TO 1000
  122 LL = 1
      DO 130 L = 1,NMXTP,5
      READ (IR,23) COFAT(L),COFAT(L+1),COFAT(L+2),COFAT(L+3),
     1 COFAT(L+4),LM
      IF ( LL .EQ. LM ) GO TO 125
      WRITE (IW,26) LL,LM
      GO TO 1000
  125 LL = LL + 5
  130 CONTINUE
      IF ( TITB(3) .LE. 0.0 ) GO TO 135
      WRITE (IW,38) ALDA
      DO 132 L = 1,NMXST,10
      L1 = L - 1
      WRITE (IW,40) L1,COFAS(L),COFAS(L+1),COFAS(L+2),COFAS(L+3),
     1 COFAS(L+4),COFAS(L+5),COFAS(L+6),COFAS(L+7),COFAS(L+8),COFAS(L+9)
  132 CONTINUE
  135 IF ( TITB(4) .LE. 0.0 ) GO TO 140
      WRITE (IW,42) ALDA
      DO 138 L = 1,NMXTP,10
      L1 = L - 1
      WRITE (IW,40) L1,COFAT(I  ,COFAT(L+1),COFAT(L+2),COFAT(L+3),
     1 COFAT(L+4),COFAT(L+5)   JFAT(L+6),COFAT(L+7),COFAT(L+8),COFAT(L+9)
  138 CONTINUE
  140 CONTINUE
C
C       PRINT OUT VARIOUS NORMAL OPTICAL THICKNESSES OF THE
C       ENTIRE ATMOSPHERIC MODEL...
C
      TAUBSR = (TITB(1)/1000.0) * TAUBSR
      TEMA = TITB(2) * OZABS
      TEMB = TITB(3) * BSCAST
      TEMC = TITB(3) * BABSST
      TEMD = TITB(4) * BSCATP
```

```
      TEME = TITB(4) * BABSTP
      TAUTOT = TAUBSR + TEMA + TEMB + TEMC + TEMD + TEME
      WRITE ( IW,44) NMOD,ALDA,TAUBSR,TEMA,TEMB,TEMC,TEMD,TEME,TAUTOT
      WRITE (IW,32) NMOD,TITB(1),TITB(2)
      WRITE (IW,36) TITB(9),TITB(10),TITB(11),TITB(5),TITB(6),TITB(3)
      WRITE (IW,34) TITB(12),TITB(13),TITB(14),TITB(7),TITB(8),TITB(4)
      IF ( TAUTOT .LE. 5.0 ) GO TO 142
      WRITE (IW,45) TAUTOT
      GO TO 1000
  142 CONTINUE
C
C       DIVIDE BASIC LAYERS WITH DELTA TAU GREATER THAN 0.02 INTO
C       SUB-LAYERS SO THAT DELTA TAU OF NO RESULTANT LAYER EXCEEDS
C       0.02,,,,,,
C                         AND THEN,,,,,
C       COMPUTE ATTENUATION FACTORS FOR THE INCOMING DIRECT SOLAR
C       RADIATION FOR ALL TEN DIFFERENT DIRECTIONS,
C       AND AT ALL LAYERS.....
C
      TAU(1) = 0.0
      INEW(1) = 1
      DO 144 J = 1,10
      ATEN(1,J) = 1.0
      A(J) = 0.0
  144 CONTINUE
      C(1) = TAUBSR/TITB(1)
      L1 = 1
      DO 160 L = 1,NBLYR
      C(2) = PRTH(L) * C(1)
      C(3) = OZOTH(L) * OZABS
      C(4) = STDUST(L) * BSCAST
      C(5) = STDUST(L) * BABSST
      C(6) = TPDUST(L) * BSCATP
      C(7) = TPDUST(L) * BABSTP
      B(L) = C(2) + C(3) + C(4) + C(5) + C(6) + C(7)
      IF ( B(L) .GT. 0.02 ) GO TO 146
      N = 1
      GO TO 148
  146 N = B(L)/0.02 + 1
  148 TEMA = 1.0/N
      C(2) = TEMA * C(2)
      C(4) = TEMA * C(4)
      C(6) = TEMA * C(6)
      C(8) = TEMA * B(L)
      L2 = L1 + N - 1
      C(9) = 1.0/C(8)
      IF ( L2 .LE. 300 ) GO TO 149
      WRITE (IW,47)
      GO TO 1000
  149 CONTINUE
      DO 150 LJ = L1,L2
      ICHCK(LJ) = 0
      OMEGR(LJ) = C(2) * C(9)
      OMEGST(LJ) = C(4) * C(9)
      OMEGTP(LJ) = C(6) * C(9)
```

```
      DTAU(LJ) = C(8)
      DTAUH(LJ) = 0.5 * DTAU(LJ)
      TAU(LJ+1) = TAU(LJ) + DTAU(LJ)
  150 CONTINUE
      ICHCK(L1) = 11
      DO 158 J = 1,10
      TEMB = 0.0
      DO 152 K = 1,L
      TEMB = TEMB + B(K) * DELS(K,J,L)
  152 CONTINUE
      DO 156 LJ = L1,L2
      LJ1 = LJ + 1
      TEMC = A(J) + TEMA * (TEMB - A(J)) * (LJ1 -L1)
      IF ( TEMC .GT. 100.0 ) GO TO 154
      ATEN(LJ1,J) = -EXP(-TEMC)
      GO TO 156
  154 ATEN(LJ1,J) = 0.0
  156 CONTINUE
      A(J) = TEMB
  158 CONTINUE
      L1 = L1 + N
      INEW(L+1) = L1
  160 CONTINUE
      MXNLYR = L2
      MXNLVL = MXNLYR + 1
      DO 162 L = 1,MXNLVL
      DO 161 J = 1,18
      BTEN(L,J) = EXP(-TAU(L)/AMU(J))
  161 CONTINUE
  162 CONTINUE
C
C       DETERMINE NTR, THE UPPER LIMIT OF THE LEGENDRE SERIES FOR THE
C       MULTIPLE SCATTERING CALCULATIONS,,,,, AND THEN,,,,
C       DETERMINE POSITIONS OF THE VARIOUS CONDITIONING POINTS...
C
      IF ( NMXST .GT. 0  .OR. NMXTP .GT. 0 ) GO TO 165
      NTR = 40
      GO TO 175
  165 NTR = 60
      IF ( NMXTP .GT. 0 ) GO TO 168
      GO TO 175
  168 IF ( NMXTP .GT. 180 ) GO TO 171
      GO TO 175
  171 IF ( NMXTP .GT. 240 ) GO TO 173
      NTR = 80
      GO TO 175
  173 NTR = 100
  175 NTR2 = NTR/2
      WRITE (IW,10)
      WRITE (IW,49) NTR
      DISTAN = 10.0/NTR
      NUMCON = TAU(MXNLVL)/DISTAN + 4.0001
      IF ( TAU(MXNLVL) .GT. 4.0 .AND. NTR .GT. 60 ) NUMCON = NUMCON + 10
      IF ( TAU(MXNLVL) .GT. 4.0 .AND. NTR .GT. 80 ) NUMCON = NUMCON + 16
      IF ( NUMCON .LE. 100 ) GO TO 180
```

```
      WRITE (IW,5) NUMCON
      GO TO 1000
  180 NUMCO1 = NUMCON - 1
      ICPOS(1) = 1
      TEMA = TAU(MXNLVL)/NUMCO1
      TEMB = TEMA
      J = 2
      DO 185 I = 1,MXNLVL
      IF ( TAU(I) .LE. TEMB ) GO TO 185
      ICPOS(J) = I
      J = J + 1
      TEMB = TEMB + TEMA
  185 CONTINUE
      ICPOS(NUMCON) = MXNLVL
      DO 186 I = 1,NUMCON
      II = ICPOS(I)
      WRITE (IW,51) I,TAU(II),II
  186 CONTINUE
      CALL SUBSTA ( OMEGR,COFAR,OMEGST,COFAS,OMEGTP,COFAT,MXNLYR,NTR,
     1 DTAUH,ATEN,FNYN,CAPLAM,CAPLX,CAPLY)
C
C      COMPUTE PRIMARY-SCATTERED CONTRIBUTION TO THE EMERGENT RADIATION
C      FOR ALL CASES OF THE UNIDIRECTIONAL ILLUMINATION FROM ABOVE...
C
      LIMIT = MAX0(NMXST,NMXTP)
      DO 199 N = 1,10
      DO 198 J = 1,18
      TEMB = 0.0
      DO 197 L = 1,MXNLYR
      L1 = L + 1
      TEMC = -0.5 * (ATEN(L,N) * BTEN(L,J) + ATEN(L1,N) * BTEN(L1,J))
      TEMA = 0.0
      DO 190 I = 1,NTR
      TEMA = TEMA + CAPLAM(I,L) * FNYP(I,J) * FNYN(I,N)
  190 CONTINUE
      NTRA = NTR + 1
      IF ( LIMIT .LE. NTR ) GO TO 192
      DO 191 I = NTRA,LIMIT
      TEMA = TEMA + (COFAS(I) * OMEGST(L) + COFAT(I) * OMEGTP(L)) *
     1 FNYP(I,J) * FNYN(I,N)
  191 CONTINUE
  192 CONTINUE
      TEMB = TEMB + 0.25 * TEMC * TEMA * DTAU(L)
  197 CONTINUE
      EIN(J,N) = TEMB
  198 CONTINUE
  199 CONTINUE
C
C      COMPUTE SOURCE TERMS DUE TO ISOTROPIC ILLUMINATION FROM BELOW....
C      AND ALSO,,,,,,
C      PRIMARY-SCATTERED CONTRIBUTION TO THE EMERGENT RADIATION.......
C
      DO 201 J = 1,18
      EIN(J,11) = 0.0
  201 CONTINUE
```

```
      TEMA = TAU(MXNLVL) - TAU(1)
      DO 220 I = 1,NTR
      READ (15'I) AJVD
      TEME = -0.5/(2*I-1)
      CALL POLATE (AJVD,TEMA,TEMB)
      IF ( I .NE. 2 ) GO TO 203
      FXS(1,11) = 6.283185 * TEMB
  203 CONTINUE
      DO 210 L = 1,MXNLYR
      L1 = L + 1
      TEMC = TAU(MXNLVL) - TAU(L1)
      CALL POLATE ( AJVD,TEMC,TEMD)
      CAPLY(I,L,11) = CAPLAM(I,L) * TEME * DTAU(L) * (TEMB + TEMD)
      DO 205 J = 1,18
      EIN(J,11) = EIN(J,11) + 0.25 * (BTEN(L,J) * TEMB + BTEN(L1,J) *
     1 TEMD) * DTAU(L) * CAPLAM(I,L) * FNYP(I,J)
  205 CONTINUE
      IF ( I .NE. 2 ) GO TO 208
      FXS(L1,11) = 6.283185 * TEMD
  208 TEMB = TEMD
  210 CONTINUE
  220 CONTINUE
C
C       SET ELEMENTS OF THE A VECTOR TO ZERO FOR ALL VALUES OF THETA
C       SUB ZERO, AND ALSO FOR THE CASE OF ISOTROPIC ILLUMINATION,
C       AND THEN FORM THE MATRIX F SUB 1...
C
      CALL SUBSTB ( AVECT,FMAT,GMAT,NTR,NTR2)
C
C       GENERARE F SUB J MATRIX AND A SUB J VECTORS FOR ALL
C       LAYERS AND FOR ALL POSITIONS OF THE SUN, AS WELL AS THE
C       CASE OF ILLUMINATION FROM BELOW....
C
      KKK = 2
      NBAS = 0
      DO 400 L = 1,MXNLYR
      IF ( L .EQ. 1 ) GO TO 295
      IF ( ICHCK(L) .EQ. 0 ) GO TO 325
  295 CONTINUE
      NBAS = NBAS + 1
      IPITE(L) = NBAS
      CALL PITRIX (AL,CAPLX(1,L),AR,PIMAT,TEM,DINV,B,C,IP,LIMU,NTR)
      NBS1 = 4*NBAS - 3
      NBS2 = NBS1 + 1
      NBS3 = NBS2 + 1
      NBS4 = NBS3 + 1
      WRITE (17'NBS1) BREKA
      WRITE (17'NBS2) BREKB
      WRITE (17'NBS3) BREKC
      WRITE (17'NBS4) BREKD
      GO TO 327
  325 IPITE(L) =NBAS
  327 CONTINUE
      CALL SUBSTC ( A,PIMAT,FMAT,DINV,CAPLY,AVECT,NTR,NTR2,L)
C
```

```
C       COMPUTE U AND T MATRIXES, AS WELL AS U AND T VECTORS
C       IF THE LEVEL CORRESPONDS TO ONE OF THE CONDITIONING POINTS...
C
      IF ( (L+1) .NE. ICPOS(KKK)) GO TO 400
      CALL SUBSTD ( CINV,FMAT,NTR2)
      CALL SOLISY(1,CINV,CIMAT,TEM,B,A,IP,NTR2,ITR,C,D)
      WRITE (IW,53) ITR,KKK
      IF ( ITR .LE. 0 ) GO TO 1000
      KKM = KKK - 1
      CALL SUBSTE ( TMAT,CIMAT,FMAT,UMAT,NTR2 )
      WRITE (11'KKM) UMAT
      WRITE (12'KKM) TMAT
      NTR21 = NTR2 + 1
      CALL SUBSTF (FMAT,UMAT,NTR2)
      CALL SUBSTG (TVECT,AVECT,UMAT,UVECT,NTR,NTR2,NTR21)
      WRITE (13'KKM) TVECT
      WRITE (14'KKM) UVECT
      KKK = KKK + 1
  400 CONTINUE
C
C       SOLVE THE LINEAR SYSTEM TO OBTAIN VALUES OF THE ELEMENTS
C       OF THE L SUB K VECTOR CORRESPONDING TO THE CONDITIONING
C       POINT FOR THE LOWER BOUNDARY OF THE ATMOSPHERE....
C
      K = NUMCO1
      CALL SUBSTH (DINV,UMAT,GMAT,NTR2)
C
C       DINV NOW CONTAINS BOTTOM HALF OF RECTANGULAR MATRIX
C       U SUB 2      MINUS     G MATRIX......
C
      READ (14'K) UVECT
      DO 600 N = 1,11
      ISW(N) = 0
      DO 560 I = 1,NTR2
      A(I) = UVECT(I,N)
  560 CONTINUE
C
C       A NOW CONTAINS BOTTOM HALF OF THE U SUB 2 VECTOR
C       BUT WITH OPPOSITE SUGN....
C
      CALL SOLISY (2,DINV,PIMAT,TEM,B,A,IP,NTR2,ITR,C,D)
      IF ( N .EQ. 11) GO TO 562
      WRITE (IW,55) THETO(N),ITR
      GO TO 563
  562 CONTINUE
      WRITE (IW,57) ITR
  563 CONTINUE
      IF ( ITR .GT. 0 ) GO TO 565
      ISW(N) = 11
  565 CONTINUE
      DO 570 I = 1,NTR2
      VECL2(I,N) = B(I)
  570 CONTINUE
      CALL SUBSTI (N,VECL2,GMAT,NTR2)
  600 CONTINUE
```

```
      SBAR = -2.0 * VECL2(NTR2+1,11)
C
C      COMPUTE FLUXES AT ALL LEVELS AFTER COMPUTING L SUB (K-1),
C      L SUB (K-2),--------, L SUB 1 VECTORS....
C
      K = NUMCO1
  615 K1 = K - 1
      READ (13'K) TVECT
      IF ( K1 .EQ. 0 ) GO TO 617
      READ (11'K1) UMAT
      READ (14'K1) UVECT
  617 CONTINUE
      CALL SUBSTJ (ISW,K1,NTR2,VECL1,VECL2,TVECT,AVECT,UVECT,
     1 TMAT,UMAT,GMAT)
      IF ( K1 .EQ. 0 ) GO TO 710
      READ (12'K1) TMAT
  710 CONTINUE
      LMIN = ICPOS(K)
      LMAX = ICPOS(K+1)
      CALL FLUX (AMUO,ATEN,AVECT,FXS,FXU,FXD,FXN,NTR,LMIN,ISW)
      CALL SUBSTK (AMOMT,AVECT,NTR,NTR2)
      LMIN = LMIN + 1
      DO 800 L = LMIN,LMAX
      L1 = L - 1
      IF ( L .EQ. LMIN ) GO TO 725
      IF ( ICHCK(L1) .EQ. 0 ) GO TO 730
  725 NBS1 = 4 * IPITE(L1) - 3
      NBS2 = NBS1 + 1
      NBS3 = NBS2 + 1
      NBS4 = NBS3 + 1
      READ (17'NBS1) BREKA
      READ (17'NBS2) BREKB
      READ (17'NBS3) BREKC
      READ (17'NBS4) BREKD
  730 CONTINUE
      CALL SUBSTL (B,DINV,CAPLY,PIMAT,AVECT,NTR,L1)
      CALL FLUX (AMUO,ATEN,AVECT,FXS,FXU,FXD,FXN,NTR,L,ISW)
      CALL SUBSTK (BMOMT,AVECT,NTR,NTR2)
      CALL SUBSTM (CAPLAM,BTEN,AMOMT,BMOMT,FNYP,DTAUH,EIN,NTR,L,L1)
  800 CONTINUE
      K = K - 1
      DO 905 N = 1,11
      DO 900 I = 1,NTR
      VECL2(I,N) = VECL1(I,N)
  900 CONTINUE
  905 CONTINUE
      IF ( K .GT. 0 ) GO TO 615
      DO 915 N = 1,11
      DO 910 J = 1,18
      EIN(J,N) = EIN(J,N)/AMU(J)
  910 CONTINUE
  915 CONTINUE
      DO 918 J = 1,18
      EIN(J,11) = EIN(J,11) + BTEN(MXNLVL,J)
  918 CONTINUE
```

```
C                                                                       SITBB606
C        PRINT OUT FLUXES.....                                          SITBB607
C                                                                       SITBB608
      WRITE (IW,10)                                                     SITBB609
      DO 950 N = 1,11                                                   SITBB610
      IF ( N .EQ. 11 ) GO TO 920                                        SITBB611
      WRITE (IW,61) NMOD,ALDA,THETO(N)                                  SITBB612
      GO TO 925                                                         SITBB613
  920 WRITE ( IW,63) NMOD,ALDA                                          SITBB614
  925 WRITE ( IW,65)                                                    SITBB615
      NN = NBLYR/2                                                      SITBB616
      NN = 2 * NN                                                       SITBB617
      IF ( NN .EQ. NBLYR ) GO TO 927                                    SITBB618
      LMAX = NBLYR                                                      SITBB619
      GO TO 928                                                         SITBB620
  927 LMAX = NBLYR - 1                                                  SITBB621
  928 DO 930 L = 1,LMAX,2                                               SITBB622
      L1 = L + 1                                                        SITBB623
      L2 = INEW(L)                                                      SITBB624
      L3 = INEW(L1)                                                     SITBB625
      WRITE (IW,67) L,FXS(L2,N),FXD(L2,N),FXU(L2,N),FXN(L2,N),          SITBB626
     1 L1,FXS(L3,N),FXD(L3,N),FXU(L3,N),FXN(L3,N)                       SITBB627
  930 CONTINUE                                                          SITBB628
      IF ( NN .NE. NBLYR ) GO TO 940                                    SITBB629
      L1 = NBLYR + 1                                                    SITBB630
      L2 = INEW(L1)                                                     SITBB631
      WRITE (IW,69) L1,FXS(L2,N),FXD(L2,N),FXU(L2,N),FXN(L2,N)          SITBB632
  940 CONTINUE                                                          SITBB633
  950 CONTINUE                                                          SITBB634
      WRITE (IW,71) SBAR                                                SITBB635
C                                                                       SITBB636
C        PRINT OUT INTENSITY OF THE EMERGENT RADIATION.....             SITBB637
C                                                                       SITBB638
      DO 970 N = 1,10                                                   SITBB639
      TEMA = (FXS(MXNLVL,N) + FXD(MXNLVL,N))/3.141593                   SITBB640
      DO 960 J = 1,18                                                   SITBB641
      EIC(J,N,ILDA) = EIN(J,N)                                          SITBB642
      TIC(J,N,ILDA) = TEMA * EIN(J,11)                                  SITBB643
  960 CONTINUE                                                          SITBB644
  970 CONTINUE                                                          SITBB645
      SSBBRR(ILDA) = SBAR                                               SITBB646
      WRITE (16'NMOD) TITB,EIC,TIC,SSBBRR                               SITBB647
      WRITE (IW,73) NMOD,ALDA                                           SITBB648
      WRITE (IW,75) (THETO(N),N=1,10)                                   SITBB649
      WRITE (IW,77) (THETA(J),AMU(J),(EIC(J,N,ILDA),N=1,10),J=1,18)     SITBB650
      WRITE (IW,79)                                                     SITBB651
      WRITE (IW,77) (THETA(J),AMU(J),(TIC(J,N,ILDA),N=1,10),J=1,18)     SITBB652
      WRITE (IW,71) SSBBRR(ILDA)                                        SITBB653
      CALL TIMDAT (DATE,HOUR,ITVE,ITRE)                                 SITBB654
      TIMV = (ITVE - ITVB) * 0.001                                      SITBB655
      TIMR = (ITRE - ITRB) * 0.001                                      SITBB656
      WRITE (6,95) NMOD,ALDA,TIMV,TIMR                                  SITBB657
      GO TO 108                                                         SITBB658
 1000 RETURN                                                            SITBB659
      END                                                               SITBB660
```

VII. INPUT FOR A TEST RUN

7.1 <u>Input for SITAA</u>: (See page 106.)

000

0.5773503	0.0	0.0	0.0	0.0	ZERCES OF P SUB 2
0.7745967	0.0	0.0	0.0	0.0	ZEROES OF P SUB 3
0.3399810	0.8611363	0.0	0.0	0.0	ZEROES OF P SUB 4
0.5384693	0.9061798	0.0	0.0	0.0	ZEROES OF P SUB 5
0.2386192	0.6612094	0.9324695	0.0	0.0	ZEROES OF P SUB 6
0.4058452	0.7415312	0.9491079	0.0	0.0	ZEROES OF P SUB 7
0.1834346	0.5255324	0.7966665	0.9602899	0.0	ZEROES OF P SUB 8
0.3242534	0.6133714	0.8360311	0.9681602	0.0	ZEROES OF P SUB 9
0.1488743	0.4333954	0.6794096	0.8650634	0.9739065	ZEROES OF P SUB 10
0.2695432	0.5190961	0.7301520	0.8870626	0.9782287	ZEROES OF P SUB 11
0.1252334	0.3678315	0.5873180	0.7699027	0.9041173	ZEROES OF P SUB 12
0.9815606	0.0	0.0	0.0	0.0	ZEROES OF P SUB 12
0.2304583	0.4484928	0.6423493	0.8015781	0.9175984	ZEROES OF P SUB 13
0.9841831	0.0	0.0	0.0	0.0	ZEROES OF P SUB 13
0.1080549	0.3191124	0.5152486	0.6872929	0.8272013	ZEROES OF P SUB 14
0.9284349	0.9862838	0.0	0.0	0.0	ZEROES OF P SUB 14
0.2011941	0.3941513	0.5709722	0.7244177	0.8482066	ZEROES OF P SUB 15
0.9372734	0.9879925	0.0	0.0	0.0	ZEROES OF P SUB 15
0.0950125	0.2816036	0.4580168	0.6178762	0.7554044	ZEROES OF P SUB 16
0.8656312	0.9445750	0.9894009	0.0	0.0	ZEROES OF P SUB 16
0.1784842	0.3512318	0.5126905	0.6576712	0.7815140	ZEROES OF P SUB 17
0.8802392	0.9506755	0.9905755	0.0	0.0	ZEROES OF P SUB 17
0.0847750	0.2518862	0.4117512	0.5597708	0.6916870	ZERCES OF P SUB 18
0.8037050	0.8926025	0.9558239	0.9915652	0.0	ZEROES OF P SUB 18
0.1603586	0.3165641	0.4645707	0.6005453	0.7209662	ZEROES OF P SUB 19
0.8227147	0.9031559	0.9602082	0.9924068	0.0	ZEROES OF P SUB 19
0.0765265	0.2277859	0.3737061	0.5108670	0.6360537	ZEROES OF P SUB 20
0.7463319	0.8391170	0.9122344	0.9639719	0.9931286	ZEROES OF P SUB 20
0.1455619	0.2880213	0.4243421	0.5516188	0.6671388	ZEROES OF P SUB 21
0.7684400	0.8533634	0.9200993	0.9672268	0.9937522	ZEROES OF P SUB 21
0.0697393	0.2078604	0.3419358	0.4693558	0.5876404	ZEROES OF P SUB 22
0.6944873	0.7878168	0.8658126	0.9269568	0.9700605	ZERCES OF P SUB 22
0.9942946	0.0	0.0	0.0	0.0	ZEROES OF P SUB 22
0.1332568	0.2641357	0.3903010	0.5095015	0.6196099	ZEROES OF P SUB 23
0.7186614	0.8048884	0.8767524	0.9329711	0.9725425	ZEROES OF P SUB 23
0.9947693	0.0	0.0	0.0	0.0	ZEROES OF P SUB 23
0.0640569	0.1911189	0.3150427	0.4337935	0.5454215	ZEROES OF P SUB 24
0.6480937	0.7401242	0.8200020	0.8864155	0.9382746	ZEROES CF P SUB 24
0.9747286	0.9951872	0.0	0.0	0.0	ZEROES OF P SUB 24
0.1228647	0.2438669	0.3611723	0.4730027	0.5776629	ZEROES OF P SUB 25
0.6735664	0.7592593	0.8334426	0.8949920	0.9429746	ZEROES OF P SUB 25
0.9766639	0.9955570	0.0	0.0	0.0	ZEROES OF P SUB 25
0.0592301	0.1768588	0.2920048	0.4030518	0.5084407	ZEROES OF P SUB 26
0.6066923	0.6964273	0.7763859	0.8454459	0.9026379	ZEROES OF P SUB 26
0.9471591	0.9783854	0.9958857	0.0	0.0	ZERCES OF P SUB 26
0.1139726	0.2264594	0.3359939	0.4411483	0.5405516	ZEROES OF P SUB 27
0.6329080	0.7170135	0.7917716	0.8562079	0.9094823	ZEROES OF P SUB 27
0.9509006	0.9799235	0.9961793	0.0	0.0	ZEROES OF P SUB 27
0.0550793	0.1645693	0.2720616	0.3762515	0.4758742	ZEROES OF P SUB 28
0.5697205	0.6566511	0.7356109	0.8056414	0.8658925	ZEROES OF P SUB 28
0.9156330	0.9542593	0.9813032	0.9964425	0.0	ZERCES OF P SUB 28
0.1062782	0.2113523	0.3140316	0.4131529	0.5075930	ZEROES OF P SUB 29
0.5962818	0.6782145	0.7524629	0.8181855	0.8746378	ZERCES OF P SUB 29
0.9211802	0.9572856	0.9825455	0.9966794	0.0	ZEROES OF P SUB 29

0.0514718	0.1538699	0.2546369	0.3527047	0.4470338	ZEROES OF P SUB	30
0.5366241	0.6205262	0.6978505	0.7677774	0.8295658	ZEROES OF P SUB	30
0.8825605	0.9262000	0.9600219	0.9836681	0.9968935	ZEROES OF P SUB	30
0.0995553	0.1981212	0.2947181	0.3883859	0.4781938	ZEROES OF P SUB	31
0.5632492	0.6427067	0.7157768	0.7817331	0.8399203	ZEROES OF P SUB	31
0.8897600	0.9307570	0.9625039	0.9846859	0.9970875	ZEROES OF P SUB	31
0.0483077	0.1444720	0.2392874	0.3318686	0.4213513	ZEROES OF P SUB	32
0.5068999	0.5877158	0.6630443	0.7321821	0.7944838	ZEROES OF P SUB	32
0.8493676	0.8963212	0.9349061	0.9647623	0.9856115	ZEROES OF P SUB	32
0.9972639	0.0	0.0	0.0	0.0	ZEROES OF P SUB	32
0.0936311	0.1864393	0.2776091	0.3663393	0.4518500	ZEROES OF P SUB	33
0.5333899	0.6102423	0.6817320	0.7472305	0.8061624	ZEROES OF P SUB	33
0.8580097	0.9023168	0.9386944	0.9668229	0.9864557	ZEROES OF P SUB	33
0.9974247	0.0	0.0	0.0	0.0	ZEROES OF P SUB	33
0.0455098	0.1361524	0.2256667	0.3133111	0.3983593	ZEROES OF P SUB	34
0.4801065	0.5578755	0.6310217	0.6989391	0.7610649	ZEROES OF P SUB	34
0.8168842	0.8659346	0.9078097	0.9421624	0.9687083	ZEROES OF P SUB	34
0.9872278	0.9975718	0.0	0.0	0.0	ZEROES OF P SUB	34
0.0883713	0.1760511	0.2623529	0.3466016	0.4281375	ZEROES OF P SUB	35
0.5063228	0.5805453	0.6502244	0.7148145	0.7738103	ZEROES OF P SUB	35
0.8267499	0.8732191	0.9128543	0.9453451	0.9704376	ZEROES OF P SUB	35
0.9879358	0.9977066	0.0	0.0	0.0	ZEROES OF P SUB	35
0.0430182	0.1287361	0.2135009	0.2966850	0.3776725	ZEROES OF P SUB	36
0.4558639	0.5306803	0.6015677	0.6680012	0.7294892	ZEROES OF P SUB	36
0.7855762	0.8358472	0.8799298	0.9174978	0.9482730	ZEROES OF P SUB	36
0.9720277	0.9885865	0.9978305	0.0	0.0	ZEROES OF P SUB	36
0.0836704	0.1667539	0.2486678	0.3288374	0.4067005	ZEROES OF P SUB	37
0.4817109	0.5533424	0.6210926	0.6844863	0.7430788	ZEROES OF P SUB	37
0.7964592	0.8442530	0.8861250	0.9217814	0.9509723	ZEROES OF P SUB	37
0.9734930	0.9891860	0.9979446	0.0	0.0	ZEROES OF P SUB	37
0.0407851	0.1220840	0.2025705	0.2817088	0.3589724	ZEROES OF P SUB	38
0.4338472	0.5058347	0.5744560	0.6392544	0.6997987	ZEROES OF P SUB	38
0.7556859	0.8065442	0.8520350	0.8918557	0.9257413	ZEROES OF P SUB	38
0.9534663	0.9748463	0.9897395	0.9980499	0.0	ZEROES OF P SUB	38
0.0794438	0.1583853	0.2363255	0.3127716	0.3872402	ZEROES OF P SUB	39
0.4592605	0.5283773	0.5941535	0.6561732	0.7140444	ZEROES OF P SUB	39
0.7674012	0.8159063	0.8592529	0.8971671	0.9294091	ZEROES OF P SUB	39
0.9557752	0.9760987	0.9902515	0.9981474	0.0	ZEROES OF P SUB	39
0.0387724	0.1160841	0.1926976	0.2681522	0.3419941	ZEROES OF P SUB	40
0.4137792	0.4830758	0.5494671	0.6125539	0.6719567	ZEROES OF P SUB	40
0.7273183	0.7783057	0.8246122	0.8659595	0.9020988	ZEROES OF P SUB	40
0.9328128	0.9579168	0.9772599	0.9907262	0.9982377	ZEROES OF P SUB	40
0.0756233	0.1508134	0.2251396	0.2981763	0.3695050	ZEROES OF P SUB	41
0.4387173	0.5054166	0.5692209	0.6297648	0.6867015	ZEROES OF P SUB	41
0.7397048	0.7884711	0.8327212	0.8722015	0.9066859	ZEROES OF P SUB	41
0.9359770	0.9599069	0.9783387	0.9911671	0.9983216	ZEROES OF P SUB	41
0.0369489	0.1106450	0.1837368	0.2558251	0.3265161	ZEROES OF P SUB	42
0.3954239	0.4621719	0.5263957	0.5877446	0.6458834	ZEROES OF P SUB	42
0.7004946	0.7512799	0.7979621	0.8402860	0.8780206	ZEROES OF P SUB	42
0.9109597	0.9389236	0.9617594	0.9793425	0.9915773	ZEROES OF P SUB	42
0.9983996	0.0	0.0	0.0	0.0	ZEROES OF P SUB	42
0.0721530	0.1439298	0.2149562	0.2848620	0.3532826	ZEROES OF P SUB	43
0.4198614	0.4842512	0.5461163	0.6051343	0.6609973	ZEROES OF P SUB	43
0.7134142	0.7621117	0.8068360	0.8473537	0.8834538	ZEROES OF P SUB	43
0.9149479	0.9416720	0.9634866	0.9802782	0.9919596	ZEROES OF P SUB	43

0.9984723	0.0	0.0	0.0	0.0	ZEROES OF P SUB 43
0.0352892	0.1056919	0.1755680	0.2445695	0.3123525	ZEROES OF P SUB 44
0.3785794	0.4429202	0.5050544	0.5646725	0.6214773	ZEROES OF P SUB 44
0.6751861	0.7255311	0.7722615	0.8151445	0.8539666	ZEROES OF P SUB 44
0.8885342	0.9186753	0.9442395	0.9650997	0.9811518	ZEROES OF P SUB 44
0.9923164	0.9985402	0.C	0.0	0.0	ZEROES OF P SUB 44
0.0689870	0.1376452	0.2056475	0.2726698	0.3383927	ZEROES OF P SUB 45
0.4025029	0.4646951	0.5246728	0.5821502	0.6368534	ZEROES OF P SUB 45
0.6885217	0.7369088	0.7817843	0.8229342	0.8601625	ZEROES OF P SUB 45
0.8932917	0.9221639	0.9466417	0.9666083	0.9819687	ZEROES OF P SUB 45
0.9926500	0.9986036	0.0	0.0	0.0	ZEROES OF P SUB 45
0.0337722	0.1011625	0.1680912	0.2342529	0.2993458	ZEROES OF P SUB 46
0.3630729	0.4251433	0.4852739	0.5431903	0.5986283	ZEROES OF P SUB 46
0.6513348	0.7010695	0.7476054	0.7907301	0.8302468	ZEROES OF P SUB 46
0.8659754	0.8977527	0.9254338	0.9488924	0.9680214	ZEROES OF P SUB 46
0.9827337	0.9929623	0.9986630	0.0	0.0	ZEROES OF P SUB 46
0.0660869	0.1318849	0.1971061	0.2614655	0.3246815	ZEROES OF P SUB 47
0.3864778	0.4465841	0.5047376	0.5606840	0.6141787	ZEROES OF P SUB 47
0.6649877	0.7128890	0.7576729	0.7991438	0.8371201	ZEROES OF P SUB 47
0.8714360	0.9019413	0.9285027	0.9510040	0.9693468	ZEROES OF P SUB 47
0.9834510	0.9932552	0.9987187	0.0	0.0	ZEROES OF P SUB 47
0.0323802	0.0970047	0.1612224	0.2247638	0.2873625	ZEROES OF P SUB 48
0.3487559	0.4086865	0.4669029	0.5231610	0.5772247	ZEROES OF P SUB 48
0.6288674	0.6778724	0.7240341	0.7671590	0.8070662	ZEROES OF P SUB 48
0.8435883	0.8765720	0.9058791	0.9313867	0.9529877	ZEROES OF P SUB 48
0.9705916	0.9841246	0.9935302	0.9987710	0.0	ZEROES OF P SUB 48
0.0634207	0.1265860	0.1892416	0.2511352	0.3120175	ZEROES OF P SUB 49
0.3716435	0.4297730	0.4861719	0.5406132	0.5928777	ZEROES OF P SUB 49
0.6427548	0.6900438	0.7345543	0.7761069	0.8145344	ZEROES OF P SUB 49
0.8496821	0.8814084	0.9095857	0.9341003	0.9548537	ZEROES OF P SUB 49
0.9717622	0.9847579	0.9937887	0.9988202	0.0	ZEROES OF P SUB 49
0.0310983	0.0931747	0.1548906	0.2160072	0.2762882	ZEROES OF P SUB 50
0.3355002	0.3934143	0.4498063	0.5044581	0.5571583	ZEROES OF P SUB 50
0.6077029	0.6558965	0.7015525	0.7444943	0.7845558	ZEROES OF P SUB 50
0.8215821	0.8554296	0.8859680	0.9130786	0.9366566	ZEROES OF P SUB 50
0.9566110	0.9728644	0.9853541	0.9940320	0.9988664	ZEROES OF P SUB 50
0.0609611	0.1216954	0.1819770	0.2415817	0.3002876	ZEROES OF P SUB 51
0.3578765	0.4141340	0.4688509	0.5218237	0.5728552	ZEROES OF P SUB 51
0.6217557	0.6683432	0.7124445	0.7538954	0.7925417	ZEROES OF P SUB 51
0.8282398	0.8608567	0.8902712	0.9163739	0.9390675	ZEROES OF P SUB 51
0.9582678	0.9739034	0.9859160	0.9942613	0.9989100	ZEROES OF P SUB 51
0.0299141	0.0896352	0.1490355	0.2079023	0.2660248	ZEROES OF P SUB 52
0.3231950	0.3792083	0.4338641	0.4869667	0.5383262	ZEROES OF P SUB 52
0.5877586	0.6350870	0.6801419	0.7227621	0.7627950	ZEROES OF P SUB 52
0.8000973	0.8345354	0.8659862	0.8943369	0.9194861	ZEROES OF P SUB 52
0.9413439	0.9598318	0.9748839	0.9864462	0.9944776	ZEROES OF P SUB 52
0.9989511	0.0	0.0	0.0	0.0	ZEROES OF P SUB 52
0.0586851	0.1171678	0.1752467	0.2327214	0.2893939	ZEROES OF P SUB 53
0.3450688	0.3995542	0.4526622	0.5042098	0.5540193	ZEROES OF P SUB 53
0.6019190	0.6477437	0.6913356	0.7325442	0.7712277	ZEROES OF P SUB 53
0.8072525	0.8404946	0.8708393	0.8981821	0.9224286	ZEROES OF P SUB 53
0.9434954	0.9613097	0.9758102	0.9869470	0.9946819	ZEROES OF P SUB 53
0.9989899	0.0	0.0	0.0	0.0	ZEROES OF P SUB 53
0.0288167	0.0863545	0.1436054	0.2003793	0.2564875	ZEROES OF P SUB 54
0.3117437	0.3659643	0.4189693	0.4705824	0.5206323	ZEROES OF P SUB 54

0.5689528	0.6153832	0.6597694	0.7019639	0.7418265	ZEROES OF P SUB 54
0.7792249	0.8140348	0.8461405	0.8754355	0.9018223	ZEROES OF P SUB 54
0.9252134	0.9455310	0.9627076	0.9766863	0.9874206	ZEROES OF P SUB 54
0.9948751	0.9990267	0.0	0.0	0.0	ZEROES OF P SUB 54
0.0565728	0.1129643	0.1689940	0.2244823	0.2792516	ZEROES OF P SUB 55
0.3331263	0.3859339	0.4375053	0.4876752	0.5362829	ZEROES OF P SUB 55
0.5831727	0.6281945	0.6712040	0.7120634	0.7506419	ZEROES OF P SUB 55
0.7868158	0.8204693	0.8514946	0.8797923	0.9052718	ZEROES OF P SUB 55
0.9278514	0.9474589	0.9640313	0.9775157	0.9878689	ZEROES OF P SUB 55
0.9950580	0.9990614	0.0	0.0	0.0	ZEROES OF P SUB 55
0.0277970	0.0833052	0.1385558	0.1933782	0.2476029	ZEROES OF P SUB 56
0.3010623	0.3535910	0.4050269	0.4552108	0.5039877	ZEROES OF P SUB 56
0.5512068	0.5967222	0.6403931	0.6820846	0.7216678	ZEROES OF P SUB 56
0.7590204	0.7940269	0.8265791	0.8565764	0.8839261	ZEROES OF P SUB 56
0.9085436	0.9303529	0.9492865	0.9652859	0.9783017	ZEROES OF P SUB 56
0.9882937	0.9952312	0.9990943	0.0	0.0	ZEROES OF P SUB 56
0.0546072	0.1090513	0.1631701	0.2168018	0.2697866	ZEROES OF P SUB 57
0.3219662	0.3731849	0.4232899	0.4721316	0.5195643	ZEROES OF P SUB 57
0.5654464	0.6096410	0.6520162	0.6924456	0.7308083	ZEROES OF P SUB 57
0.7669901	0.8008829	0.8323855	0.8614040	0.8878517	ZEROES OF P SUB 57
0.9116497	0.9327270	0.9510206	0.9664761	0.9790472	ZEROES OF P SUB 57
0.9886966	0.9953955	0.9991256	0.0	0.0	ZEROES OF P SUB 57
0.0268470	0.0804636	0.1338483	0.1868470	0.2393069	ZEROES OF P SUB 58
0.2910769	0.3420077	0.3919523	0.4407668	0.4883105	ZEROES OF P SUB 58
0.5344463	0.5790411	0.6219664	0.6630984	0.7023186	ZEROES OF P SUB 58
0.7395137	0.7745767	0.8074063	0.8379080	0.8659938	ZEROES OF P SUB 58
0.8915827	0.9146009	0.9349821	0.9526676	0.9676062	ZEROES OF P SUB 58
0.9797550	0.9890790	0.9955515	0.9991552	0.0	ZEROES OF P SUB 58
0.0527735	0.1053999	0.1577325	0.2096255	0.2609342	ZEROES OF P SUB 59
0.3115157	0.3612289	0.4099353	0.4574992	0.5037879	ZEROES OF P SUB 59
0.5486724	0.5920277	0.6337330	0.6736719	0.7117331	ZEROES OF P SUB 59
0.7478106	0.7818039	0.8136181	0.8431646	0.8703611	ZEROES OF P SUB 59
0.8951317	0.9174074	0.9371262	0.9542330	0.9686802	ZEROES OF P SUB 59
0.9804276	0.9894424	0.9956996	0.9991834	0.0	ZEROES OF P SUB 59
0.0259598	0.0778093	0.1294491	0.1807400	0.2315436	ZEROES OF P SUB 60
0.2817229	0.3311428	0.3796701	0.4271737	0.4735258	ZEROES OF P SUB 60
0.5186014	0.5622789	0.6044406	0.6449728	0.6837663	ZEROES OF P SUB 60
0.7207165	0.7557238	0.7886937	0.8195375	0.8481720	ZEROES OF P SUB 60
0.8745199	0.8985103	0.9200785	0.9391663	0.9557223	ZEROES OF P SUB 60
0.9697013	0.9810672	0.9897879	0.9958405	0.9992101	ZEROES OF P SUB 60
0.0510589	0.1019846	0.1526442	0.2029056	0.2526377	ZEROES OF P SUB 61
0.3017106	0.3499964	0.3973692	0.4437052	0.4888836	ZEROES OF P SUB 61
0.5327866	0.5752997	0.6163118	0.6557160	0.6934096	ZEROES OF P SUB 61
0.7292941	0.7632760	0.7952666	0.8251824	0.8529455	ZEROES OF P SUB 61
0.8784832	0.9017292	0.9226226	0.9411090	0.9571402	ZEROES OF P SUB 61
0.9706743	0.9816760	0.9901167	0.9959746	0.9992356	ZEROES OF P SUB 61
0.0251293	0.0753244	0.1253292	0.1750175	0.2242636	ZEROES OF P SUB 62
0.2729432	0.3209333	0.3681128	0.4143623	0.4595652	ZEROES OF P SUB 62
0.5036071	0.5463769	0.5877664	0.6276713	0.6659906	ZEROES OF P SUB 62
0.7026275	0.7374895	0.7704886	0.8015413	0.8305693	ZEROES OF P SUB 62
0.8574992	0.8822630	0.9047981	0.9250476	0.9429604	ZEROES OF P SUB 62
0.9584912	0.9716007	0.9822559	0.9904300	0.9961023	ZEROES OF P SUB 62
0.9992599	0.0	0.0	0.0	0.0	ZEROES OF P SUB 62
0.0494522	0.0967834	0.1478728	0.1966003	0.2448468	ZEROES OF P SUB 63
0.2924941	0.3394255	0.3855264	0.4306838	0.4747872	ZEROES OF P SUB 63

0.5177288	0.5594034	0.5997091	0.6385471	0.6758225	ZEROES OF P SUB	63
0.7114441	0.7453246	0.7773813	0.8075355	0.8357136	ZEROES OF P SUB	63
0.8618465	0.8858703	0.9077263	0.9273609	0.9447261	ZEROES OF P SUB	63
0.9597794	0.9724840	0.9828088	0.9907285	0.9962240	ZEROES OF P SUB	63
0.9992839	0.0	0.0	0.0	0.0	ZEROES OF P SUB	63
0.0243503	0.0729931	0.1214628	0.1696444	0.2174236	ZEROES OF P SUB	64
0.2646872	0.3113229	0.3572202	0.4022702	0.4463660	ZEROES OF P SUB	64
0.4894031	0.5312795	0.5718956	0.6111554	0.6489655	ZEROES OF P SUB	64
0.6852363	0.7198819	0.7528199	0.7839724	0.8132653	ZEROES OF P SUB	64
0.8406293	0.8659994	0.8893154	0.9105221	0.9295692	ZEROES OF P SUB	64
0.9464114	0.9610088	0.9733268	0.9833363	0.9910134	ZEROES OF P SUB	64
0.9963401	0.9993050	0.0	0.0	0.0	ZEROES OF P SUB	64
0.0479435	0.0957767	0.1433896	0.1906727	0.2375172	ZEROES OF P SUB	65
0.2838155	0.3294609	0.3743486	0.4183753	0.4614397	ZEROES OF P SUB	65
0.5034428	0.5442879	0.5838812	0.6221315	0.6589509	ZEROES OF P SUB	65
0.6942547	0.7279617	0.7599943	0.7902790	0.8187459	ZEROES OF P SUB	65
0.8453298	0.8699693	0.8926079	0.9131934	0.9316786	ZEROES OF P SUB	65
0.9480209	0.9621828	0.9741315	0.9838398	0.9912853	ZEROES OF P SUB	65
0.9964509	0.9993261	0.0	0.0	0.0	ZEROES OF P SUB	65
0.0236181	0.0708017	0.1178273	0.1645899	0.2109853	ZEROES OF P SUB	66
0.2569099	0.3022613	0.3469382	0.3908409	0.4338715	ZEROES OF P SUB	66
0.4759339	0.5169344	0.5567814	0.5953860	0.6326620	ZEROES OF P SUB	66
0.6685264	0.7028990	0.7357031	0.7668656	0.7963170	ZEROES OF P SUB	66
0.8239914	0.8498272	0.8737667	0.8957565	0.9157475	ZEROES OF P SUB	66
0.9336951	0.9495592	0.9633046	0.9749004	0.9843209	ZEROES OF P SUB	66
0.9915450	0.9965568	0.9993462	0.0	0.0	ZEROES OF P SUB	66
0.0465240	0.0929473	0.1391693	0.1850898	0.2306095	ZEROES OF P SUB	67
0.2756298	0.3200531	0.3637832	0.4067255	0.4487869	ZEROES OF P SUB	67
0.4898763	0.5299047	0.5687855	0.6064345	0.6427700	ZEROES OF P SUB	67
0.6777134	0.7111891	0.7431244	0.7734504	0.8021012	ZEROES OF P SUB	67
0.8290148	0.8541330	0.8774013	0.8987694	0.9181909	ZEROES OF P SUB	67
0.9356239	0.9510305	0.9643773	0.9756356	0.9847808	ZEROES OF P SUB	67
0.9917933	0.9966530	0.9993654	0.0	0.0	ZEROES OF P SUB	67
0.0229287	0.0687379	0.1144026	0.1598266	0.2049146	ZEROES OF P SUB	68
0.2495716	0.2937037	0.3372182	0.3800235	0.4220296	ZEROES OF P SUB	68
0.4631482	0.5032928	0.5423789	0.5803244	0.6170495	ZEROES OF P SUB	68
0.6524769	0.6865322	0.7191436	0.7502427	0.7797640	ZEROES OF P SUB	68
0.8076455	0.8338285	0.8582579	0.8808824	0.9016543	ZEROES OF P SUB	68
0.9205301	0.9374700	0.9524384	0.9654038	0.9763390	ZEROES OF P SUB	68
0.9852209	0.9920309	0.9967548	0.9993838	0.0	ZEROES OF P SUB	68
0.0451862	0.0902801	0.1351896	0.1798228	0.2240888	ZEROES OF P SUB	69
0.2678969	0.3111577	0.3537828	0.3956852	0.4367792	ZEROES OF P SUB	69
0.4769809	0.5162081	0.5543808	0.5914209	0.6272528	ZEROES OF P SUB	69
0.6618032	0.6950016	0.7267801	0.7570739	0.7858210	ZEROES OF P SUB	69
0.8129628	0.8384437	0.8622117	0.8842182	0.9044184	ZEROES OF P SUB	69
0.9227708	0.9392381	0.9537866	0.9663866	0.9770123	ZEROES OF P SUB	69
0.9856421	0.9922583	0.9968475	0.9994014	0.0	ZEROES OF P SUB	69
0.0222784	0.0667910	0.1111709	0.1553301	0.1991810	ZEROES OF P SUB	70
0.2426364	0.2856100	0.3280166	0.3697720	0.4107932	ZEROES OF P SUB	70
0.4509988	0.4903090	0.5286457	0.5659329	0.6020964	ZEROES OF P SUB	70
0.6370646	0.6707679	0.7031394	0.7341150	0.7636330	ZEROES OF P SUB	70
0.7916349	0.8180651	0.8428711	0.8660036	0.8874168	ZEROES OF P SUB	70
0.9070681	0.9249185	0.9409326	0.9550785	0.9673282	ZEROES OF P SUB	70
0.9776574	0.9860456	0.9924761	0.9969363	0.9994183	ZEROES OF P SUB	70
0.0439231	0.0877615	0.1314305	0.1748457	0.2179235	ZEROES OF P SUB	71

0.2605806	0.3027347	0.3443049	0.3852097	0.4253713	ZEROES OF P SUB	71
0.4647118	0.5031553	0.5406276	0.5770563	0.6123712	ZEROES OF P SUB	71
0.6465040	0.6793689	0.7109624	0.7411635	0.7699340	ZEROES OF P SUB	71
0.7972183	0.8229638	0.8471207	0.8696424	0.8904855	ZEROES OF P SUB	71
0.9096098	0.9269782	0.9425573	0.9563171	0.9682309	ZEROES OF P SUB	71
0.9782757	0.9864323	0.9926848	0.9970213	0.9994344	ZEROES OF P SUB	71
0.0216639	0.0649512	0.1081164	0.1510788	0.1937574	ZEROES OF P SUB	72
0.2360723	0.2779440	0.3192939	0.3600444	0.4001189	ZEROES OF P SUB	72
0.4394422	0.4779406	0.5155416	0.5521748	0.5877713	ZEROES OF P SUB	72
0.6222643	0.6555891	0.6876831	0.7184861	0.7479401	ZEROES OF P SUB	72
0.7759900	0.8025830	0.8276693	0.8512017	0.8731361	ZEROES OF P SUB	72
0.8934313	0.9120491	0.9289546	0.9441162	0.9575052	ZEROES OF P SUB	72
0.9690967	0.9788688	0.9868032	0.9928850	0.9971029	ZEROES OF P SUB	72
0.9994499	0.0	0.0	0.0	0.0	ZEROES OF P SUB	72
0.0427288	0.0853795	0.1278742	0.1701354	0.2120857	ZEROES OF P SUB	73
0.2536487	0.2947484	0.3353096	0.3752583	0.4145216	ZEROES OF P SUB	73
0.4530277	0.4907062	0.5274884	0.5633070	0.5980967	ZEROES OF P SUB	73
0.6317938	0.6643369	0.6956665	0.7257253	0.7544584	ZEROES OF P SUB	73
0.7818134	0.8077403	0.8321917	0.8551230	0.8764922	ZEROES OF P SUB	73
0.8962604	0.9143915	0.9308522	0.9456126	0.9586457	ZEROES OF P SUB	73
0.9699277	0.9794379	0.9871590	0.9930770	0.9971811	ZEROES OF P SUB	73
0.9994648	0.0	0.0	0.0	0.0	ZEROES OF P SUB	73
0.0210825	0.0632099	0.1052250	0.1470530	0.1886196	ZEROES OF P SUB	74
0.2298508	0.2706733	0.3110146	0.3508029	0.3899674	ZEROES OF P SUB	74
0.4284387	0.4661482	0.5030289	0.5390152	0.5740432	ZEROES OF P SUB	74
0.6080505	0.6409768	0.6727634	0.7033539	0.7326938	ZEROES OF P SUB	74
0.7607311	0.7874157	0.8127004	0.8365402	0.8588926	ZEROES OF P SUB	74
0.8797179	0.8989791	0.9166420	0.9326751	0.9470499	ZEROES OF P SUB	74
0.9597410	0.9707256	0.9799843	0.9875007	0.9932614	ZEROES OF P SUB	74
0.9972563	0.9994791	0.0	0.0	0.0	ZEROES OF P SUB	74
0.0415976	0.0831231	0.1245048	0.1656709	0.2065503	ZEROES OF P SUB	75
0.2470720	0.2871660	0.3267629	0.3657941	0.4041920	ZEROES OF P SUB	75
0.4418902	0.4788234	0.5149277	0.5501406	0.5844010	ZEROES OF P SUB	75
0.6176497	0.6498292	0.6808837	0.7107595	0.7394043	ZEROES OF P SUB	75
0.7667701	0.7928079	0.8174733	0.8407234	0.8625182	ZEROES OF P SUB	75
0.8828197	0.9015929	0.9188053	0.9344271	0.9484312	ZEROES OF P SUB	75
0.9607934	0.9714923	0.9805093	0.9878290	0.9934385	ZEROES OF P SUB	75
0.9973284	0.9994928	0.0	0.0	0.0	ZEROES OF P SUB	75
0.0205314	0.0615596	0.1024840	0.1432355	0.1837456	ZEROES OF P SUB	76
0.2239458	0.2637684	0.3031462	0.3420128	0.3803028	ZEROES OF P SUB	76
0.4179514	0.4548953	0.4910721	0.5264209	0.5608820	ZEROES OF P SUB	76
0.5943974	0.6269104	0.6583664	0.6887121	0.7178966	ZEROES OF P SUB	76
0.7458705	0.7725867	0.7980002	0.8220680	0.8447497	ZEROES OF P SUB	76
0.8660069	0.8858038	0.9041071	0.9208859	0.9361118	ZEROES OF P SUB	76
0.9497592	0.9618051	0.9722292	0.9810139	0.9881445	ZEROES OF P SUB	76
0.9936088	0.9973978	0.9995059	0.0	0.0	ZEROES OF P SUB	76
0.0405247	0.0809829	0.1213080	0.1614338	0.2012943	ZEROES OF P SUB	77
0.2408242	0.2799583	0.3186325	0.3567832	0.3943476	ZEROES OF P SUB	77
0.4312642	0.4674722	0.5029122	0.5375258	0.5712563	ZEROES OF P SUB	77
0.6040483	0.6358477	0.6666025	0.6962621	0.7247777	ZEROES OF P SUB	77
0.7521025	0.7781916	0.8030021	0.8264933	0.8486266	ZEROES OF P SUB	77
0.8693656	0.8886762	0.9065267	0.9228878	0.9377326	ZEROES OF P SUB	77
0.9510367	0.9627783	0.9729380	0.9814992	0.9884478	ZEROES OF P SUB	77
0.9937725	0.9974645	0.9995186	0.0	0.0	ZEROES OF P SUB	77
0.0200084	0.0599932	0.0998819	0.1396106	0.1791158	ZEROES OF P SUB	78

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0.2183341	0.2572028	0.2956596	0.3336429	0.3710919	ZEROES	OF	P	SUB	78
0.4079467	0.4441482	0.4796384	0.5143605	0.5482589	ZEROES	OF	P	SUB	78
0.5812793	0.6133688	0.6444761	0.6745514	0.7035464	ZEROES	OF	P	SUB	78
0.7314147	0.7581117	0.7835947	0.8078228	0.8307573	ZEROES	OF	P	SUB	78
0.8523614	0.8726005	0.8914422	0.9088564	0.9248151	ZEROES	OF	P	SUB	78
0.9392928	0.9522663	0.9637148	0.9736201	0.9819662	ZEROES	OF	P	SUB	78
0.9887397	0.9939300	0.9975286	0.9995308	0.0	ZEROES	OF	P	SUB	78
0.0395058	0.0789500	0.1182708	0.1574070	0.1962975	ZEROES	OF	P	SUB	79
0.2348814	0.2730986	0.3108894	0.3481947	0.3849565	ZEROES	OF	P	SUB	79
0.4211171	0.4566202	0.4914104	0.5254332	0.5586357	ZEROES	OF	P	SUB	79
0.5909660	0.6223735	0.6528092	0.6822257	0.7105769	ZEROES	OF	P	SUB	79
0.7378187	0.7639084	0.7888054	0.8124708	0.8348676	ZEROES	OF	P	SUB	79
0.8559609	0.8757176	0.8941071	0.9111005	0.9266713	ZEROES	OF	P	SUB	79
0.9407952	0.9534502	0.9646165	0.9742767	0.9824157	ZEROES	OF	P	SUB	79
0.9890207	0.9940816	0.9975904	0.9995425	0.0	ZEROES	OF	P	SUB	79
0.0195114	0.0585044	0.0974084	0.1361640	0.1747123	ZEROES	OF	P	SUB	80
0.2129945	0.2509524	0.2885281	0.3256644	0.3623048	ZEROES	OF	P	SUB	80
0.3983934	0.4338754	0.4686966	0.5028041	0.5361459	ZEROES	OF	P	SUB	80
0.5686713	0.6003306	0.6310758	0.6608599	0.6896376	ZEROES	OF	P	SUB	80
0.7173652	0.7440003	0.7695024	0.7938327	0.8169541	ZEROES	OF	P	SUB	80
0.8388315	0.8594314	0.8787226	0.8966756	0.9132631	ZEROES	OF	P	SUB	80
0.9264599	0.9422428	0.9545908	0.9654851	0.9749091	ZEROES	OF	P	SUB	80
0.9828486	0.9892913	0.9942275	0.9976499	0.9995538	ZEROES	OF	P	SUB	80
0.0385369	0.0770165	0.1153817	0.1535755	0.1915411	ZEROES	OF	P	SUB	81
0.2292221	0.2665626	0.3035071	0.3400006	0.3759890	ZEROES	OF	P	SUB	81
0.4114188	0.4462373	0.4803929	0.5138347	0.5465132	ZEROES	OF	P	SUB	81
0.5783797	0.6093869	0.6394887	0.6686405	0.6967988	ZEROES	OF	P	SUB	81
0.7239219	0.7499695	0.7749028	0.7986849	0.8212804	ZEROES	OF	P	SUB	81
0.8426557	0.8627791	0.8816206	0.8991523	0.9153482	ZEROES	OF	P	SUB	81
0.9301841	0.9436380	0.9556900	0.9663221	0.9755186	ZEROES	OF	P	SUB	81
0.9832657	0.9895520	0.9943682	0.9977072	0.9995647	ZEROES	OF	P	SUB	81
0.0190385	0.0570878	0.0950543	0.1328830	0.1705191	ZEROES	OF	P	SUB	82
0.2079079	0.2449952	0.2817274	0.3180511	0.3539136	ZEROES	OF	P	SUB	82
0.3892630	0.4240479	0.4582181	0.4917239	0.5245167	ZEROES	OF	P	SUB	82
0.5565491	0.5877745	0.6181476	0.6476246	0.6761625	ZEROES	OF	P	SUB	82
0.7037200	0.7302573	0.7557357	0.7801184	0.8033700	ZEROES	OF	P	SUB	82
0.8254567	0.8463467	0.8660095	0.8844167	0.9015416	ZEROES	OF	P	SUB	82
0.9173593	0.9318469	0.9449835	0.9567499	0.9671291	ZEROES	OF	P	SUB	82
0.9761061	0.9836678	0.9898033	0.9945038	0.9977624	ZEROES	OF	P	SUB	82
0.9995752	0.0	0.0	0.0	0.0	ZEROES	OF	P	SUB	82
0.0376143	0.0751754	0.1126301	0.1499253	0.1870084	ZEROES	OF	P	SUB	83
0.2238267	0.2603283	0.2964614	0.3321749	0.3674182	ZEROES	OF	P	SUB	83
0.4021415	0.4362956	0.4698322	0.5027038	0.5348639	ZEROES	OF	P	SUB	83
0.5662669	0.5968684	0.6266252	0.6554950	0.6834370	ZEROES	OF	P	SUB	83
0.7104117	0.7363609	0.7613079	0.7851573	0.8078953	ZEROES	OF	P	SUB	83
0.8294899	0.8499105	0.8691281	0.8871155	0.9038474	ZEROES	OF	P	SUB	83
0.9192999	0.9334513	0.9462815	0.9577723	0.9679075	ZEROES	OF	P	SUB	83
0.9766728	0.9840556	0.9900457	0.9946345	0.9978156	ZEROES	OF	P	SUB	83
0.9995853	0.0	0.0	0.0	0.0	ZEROES	OF	P	SUB	83
0.0185879	0.0557380	0.0928111	0.1297560	0.1665214	ZEROES	OF	P	SUB	84
0.2030568	0.2393115	0.2752354	0.3107790	0.3458930	ZEROES	OF	P	SUB	84
0.3805290	0.4146390	0.4481760	0.4810935	0.5133462	ZEROES	OF	P	SUB	84
0.5448893	0.5756794	0.6056738	0.6348311	0.6631111	ZEROES	OF	P	SUB	84
0.6904745	0.7168837	0.7423020	0.7666944	0.7900272	ZEROES	OF	P	SUB	84
0.8122681	0.8333864	0.8533529	0.8721399	0.8897216	ZEROES	OF	P	SUB	84

0.9060736	0.9211733	0.9349999	0.9475342	0.9587590	ZEROES OF P SUB	84
0.9686586	0.9772195	0.9844298	0.9902795	0.9947606	ZEROES OF P SUB	84
0.9978670	0.9995951	0.0	0.0	0.0	ZEROES OF P SUB	84
0.0367349	0.0734202	0.1100063	0.1464440	0.1826840	ZEROES OF P SUB	85
0.2186774	0.2543755	0.2897303	0.3246939	0.3592192	ZEROES OF P SUB	85
0.3932596	0.4267691	0.4597025	0.4920153	0.5236640	ZEROES OF P SUB	85
0.5546057	0.5847987	0.6142022	0.6427766	0.6704833	ZEROES OF P SUB	85
0.6972849	0.7231451	0.7480292	0.7719035	0.7947357	ZEROES OF P SUB	85
0.8164950	0.8371522	0.8566792	0.8750497	0.8922390	ZEROES OF P SUB	85
0.9082238	0.9229825	0.9364952	0.9487438	0.9597115	ZEROES OF P SUB	85
0.9693837	0.9777473	0.9847910	0.9905052	0.9948824	ZEROES OF P SUB	85
0.9979166	0.9996045	0.0	0.0	0.0	ZEROES OF P SUB	85
0.0181582	0.0544506	0.0906713	0.1267723	0.1627061	ZEROES OF P SUB	86
0.1984254	0.2338829	0.2690319	0.3038261	0.3382196	ZEROES OF P SUB	86
0.3721671	0.4056236	0.4385452	0.4708883	0.5026104	ZEROES OF P SUB	86
0.5336696	0.5640249	0.5936363	0.6224648	0.6504722	ZEROES OF P SUB	86
0.6776218	0.7038776	0.7292050	0.7535707	0.7769425	ZEROES OF P SUB	86
0.7992895	0.8205824	0.8407929	0.8598946	0.8778620	ZEROES OF P SUB	86
0.8946717	0.9103013	0.9247304	0.9379398	0.9499121	ZEROES OF P SUB	86
0.9606315	0.9700840	0.9782570	0.9851397	0.9907231	ZEROES OF P SUB	86
0.9949999	0.9979645	0.9996136	0.0	0.0	ZEROES OF P SUB	86
0.0358956	0.0717450	0.1075018	0.1431201	0.1785540	ZEROES OF P SUB	87
0.2137577	0.2486858	0.2832934	0.3175359	0.3513691	ZEROES OF P SUB	87
0.3847494	0.4176337	0.4499798	0.4817458	0.5128909	ZEROES OF P SUB	87
0.5433749	0.5731585	0.6022034	0.6304720	0.6579280	ZEROES OF P SUB	87
0.6845359	0.7102615	0.7350717	0.7589343	0.7818187	ZEROES OF P SUB	87
0.8036954	0.8245362	0.8443141	0.8630038	0.8805812	ZEROES OF P SUB	87
0.8970235	0.9123095	0.9264197	0.9393357	0.9510410	ZEROES OF P SUB	87
0.9615204	0.9707605	0.9787493	0.9854766	0.9909337	ZEROES OF P SUB	87
0.9951135	0.9980107	0.9996224	0.0	0.0	ZEROES OF P SUB	87
0.0177479	0.0532213	0.0886277	0.1239224	0.1590610	ZEROES OF P SUB	88
0.1939991	0.2286928	0.2630984	0.2971724	0.3308720	ZEROES OF P SUB	88
0.3641548	0.3969787	0.4293024	0.4610851	0.4922870	ZEROES OF P SUB	88
0.5228685	0.5527912	0.5820175	0.6105104	0.6382340	ZEROES OF P SUB	88
0.6651535	0.6912349	0.7164453	0.7407530	0.7641274	ZEROES OF P SUB	88
0.7865390	0.8079596	0.8283621	0.8477209	0.8660116	ZEROES OF P SUB	88
0.8832111	0.8992978	0.9142514	0.9280530	0.9406853	ZEROES OF P SUB	88
0.9521323	0.9623796	0.9714144	0.9792252	0.9858022	ZEROES OF P SUB	88
0.9911371	0.9952232	0.9980554	0.9996308	0.0	ZEROES OF P SUB	88
0.0350938	0.0701444	0.1051086	0.1399433	0.1746056	ZEROES OF P SUB	89
0.2090528	0.2432424	0.2771323	0.3106808	0.3438466	ZEROES OF P SUB	89
0.3765888	0.4088669	0.4406414	0.4718730	0.5025233	ZEROES OF P SUB	89
0.5325544	0.5619294	0.5906122	0.6185673	0.6457603	ZEROES OF P SUB	89
0.6721578	0.6977272	0.7224370	0.7462567	0.7691571	ZEROES OF P SUB	89
0.7911098	0.8120879	0.8320655	0.8510181	0.8689221	ZEROES OF P SUB	89
0.8857557	0.9014980	0.9161297	0.9296327	0.9419904	ZEROES OF P SUB	89
0.9531876	0.9632105	0.9720466	0.9796853	0.9861169	ZEROES OF P SUB	89
0.9913337	0.9953292	0.9980986	0.9996390	0.0	ZEROES OF P SUB	89
0.0173557	0.0520463	0.0866741	0.1211975	0.1555749	ZEROES OF P SUB	90
0.1897648	0.2237260	0.2574177	0.2907992	0.3238304	ZEROES OF P SUB	90
0.3564713	0.3886827	0.4204258	0.4516623	0.4823546	ZEROES OF P SUB	90
0.5124657	0.5419593	0.5707999	0.5989527	0.6263838	ZEROES OF P SUB	90
0.6530602	0.6789497	0.7040211	0.7282442	0.7515899	ZEROES OF P SUB	90
0.7740299	0.7955373	0.8160861	0.8356516	0.8542103	ZEROES OF P SUB	90
0.8717396	0.8882186	0.9036273	0.9179473	0.9311612	ZEROES OF P SUB	90

0.9432531	0.9542085	0.9640141	0.9726582	0.9801303	ZEROES OF P SUB	90
0.9864214	0.9915239	0.9954318	0.9981404	0.9996470	ZEROES OF P SUB	90
0.0343271	0.0686137	0.1028195	0.1369040	0.1708272	ZEROES OF P SUB	91
0.2045490	0.2380297	0.2712299	0.3041103	0.3366323	ZEROES OF P SUB	91
0.3687574	0.4004479	0.4316664	0.4623761	0.4925407	ZEROES OF P SUB	91
0.5221248	0.5510934	0.5794124	0.6070485	0.6339690	ZEROES OF P SUB	91
0.6601423	0.6855374	0.7101244	0.7338744	0.7567594	ZEROES OF P SUB	91
0.7787523	0.7998273	0.8199595	0.8391252	0.8573018	ZEROES OF P SUB	91
0.8744679	0.8906032	0.9056887	0.9197067	0.9326406	ZEROES OF P SUB	91
0.9444751	0.9551964	0.9647917	0.9732499	0.9805608	ZEROES OF P SUB	91
0.9867159	0.9917079	0.9955310	0.9981808	0.9996546	ZEROES OF P SUB	91
0.0169805	0.0509220	0.0848047	0.1185896	0.1522377	ZEROES OF P SUB	92
0.1857103	0.2189686	0.2519744	0.2846895	0.3170763	ZEROES OF P SUB	92
0.3490974	0.3807159	0.4118952	0.4425995	0.4727933	ZEROES OF P SUB	92
0.5024417	0.5315107	0.5599666	0.5877767	0.6149088	ZEROES OF P SUB	92
0.6413317	0.6670149	0.6919288	0.7160446	0.7393345	ZEROES OF P SUB	92
0.7617717	0.7833303	0.8039854	0.8237132	0.8424909	ZEROES OF P SUB	92
0.8602969	0.8771107	0.8929128	0.9076851	0.9214104	ZEROES OF P SUB	92
0.9340730	0.9456582	0.9561528	0.9655445	0.9738226	ZEROES OF P SUB	92
0.9809775	0.9870009	0.9918860	0.9956271	0.9982199	ZEROES OF P SUB	92
0.9996621	0.0	0.0	0.0	0.0	ZEROES OF P SUB	92
0.0335931	0.0671483	0.1006277	0.1339935	0.1672081	ZEROES OF P SUB	93
0.2002339	0.2330336	0.2655703	0.2978072	0.3297080	ZEROES OF P SUB	93
0.3612365	0.3923573	0.4230351	0.4532354	0.4829241	ZEROES OF P SUB	93
0.5120676	0.5406331	0.5685883	0.5959016	0.6225423	ZEROES OF P SUB	93
0.6484802	0.6736860	0.6981314	0.7217887	0.7446312	ZEROES OF P SUB	93
0.7666331	0.7877696	0.8080168	0.8273519	0.8457531	ZEROES OF P SUB	93
0.8631995	0.8796715	0.8951505	0.9096190	0.9230607	ZEROES OF P SUB	93
0.9354604	0.9468040	0.9570789	0.9662734	0.9743771	ZEROES OF P SUB	93
0.9813809	0.9872769	0.9920584	0.9957200	0.9982578	ZEROES OF P SUB	93
0.9996693	0.0	0.0	0.0	0.0	ZEROES OF P SUB	93
0.0166212	0.0498452	0.0830141	0.1160913	0.1490402	ZEROES OF P SUB	94
0.1818244	0.2144076	0.2467539	0.2788276	0.3105931	ZEROES OF P SUB	94
0.3420154	0.3730597	0.4036917	0.4338777	0.4635841	ZEROES OF P SUB	94
0.4927783	0.5214279	0.5495013	0.5769674	0.6037960	ZEROES OF P SUB	94
0.6299572	0.6554224	0.6801632	0.7041524	0.7273635	ZEROES OF P SUB	94
0.7497707	0.7713494	0.7920757	0.8119266	0.8308804	ZEROES OF P SUB	94
0.8489159	0.8660133	0.8821537	0.8973192	0.9114931	ZEROES OF P SUB	94
0.9246597	0.9368045	0.9479141	0.9579761	0.9669795	ZEROES OF P SUB	94
0.9749143	0.9817717	0.9875442	0.9922254	0.9958101	ZEROES OF P SUB	94
0.9982944	0.9996762	0.0	0.0	0.0	ZEROES OF P SUB	94
0.0328899	0.0657442	0.0985273	0.1312038	0.1637384	ZEROES OF P SUB	95
0.1960958	0.2282410	0.2601392	0.2917559	0.3230570	ZEROES OF P SUB	95
0.3540085	0.3845769	0.4147291	0.4444326	0.4736552	ZEROES OF P SUB	95
0.5023653	0.5305318	0.5581242	0.5851127	0.6114680	ZEROES OF P SUB	95
0.6371618	0.6621660	0.6864538	0.7099987	0.7327754	ZEROES OF P SUB	95
0.7547592	0.7759263	0.7962537	0.8157196	0.8343028	ZEROES OF P SUB	95
0.8519833	0.8687418	0.8845608	0.8994217	0.9133098	ZEROES OF P SUB	95
0.9262097	0.9381073	0.9489898	0.9588455	0.9676637	ZEROES OF P SUB	95
0.9754347	0.9821508	0.9878032	0.9923871	0.9958973	ZEROES OF P SUB	95
0.9983300	0.9996830	0.0	0.0	0.0	ZEROES OF P SUB	95
0.0162767	0.0488130	0.0812975	0.1136959	0.1459737	ZEROES OF P SUB	96
0.1780969	0.2100313	0.2417432	0.2731988	0.3043649	ZEROES OF P SUB	96
0.3352085	0.3656969	0.3957976	0.4254790	0.4547094	ZEROES OF P SUB	96
0.4834580	0.5116942	0.5393881	0.5665104	0.5930324	ZEROES OF P SUB	96

0.6189258	0.6441634	0.6687183	0.6925645	0.7156768	ZEROES OF P SUB 96
0.7380306	0.7596023	0.7803690	0.8003087	0.8194003	ZEROES OF P SUB 96
0.8376235	0.8549590	0.8713885	0.8868945	0.9014606	ZEROES OF P SUB 96
0.9150714	0.9277125	0.9393703	0.9500827	0.9596883	ZEROES OF P SUB 96
0.9683268	0.9759392	0.9825173	0.9880541	0.9925439	ZEROES OF P SUB 96
0.9959818	0.9983644	0.9996895	0.0	0.0	ZEROES OF P SUB 96
0.0322155	0.0643975	0.0965127	0.1285276	0.1604092	ZEROES OF P SUB 97
0.1921242	0.2236398	0.2549232	0.2859419	0.3166638	ZEROES OF P SUB 97
0.3470570	0.3770899	0.4067313	0.4359505	0.4647171	ZEROES OF P SUB 97
0.4930012	0.5207736	0.5480053	0.5746681	0.6007344	ZEROES OF P SUB 97
0.6261770	0.6509695	0.6750663	0.6985022	0.7211930	ZEROES OF P SUB 97
0.7431351	0.7643057	0.7846828	0.8042454	0.8229730	ZEROES OF P SUB 97
0.8408463	0.8578467	0.8739565	0.8891591	0.9034386	ZEROES OF P SUB 97
0.9167801	0.9291700	0.9405952	0.9510440	0.9605055	ZEROES OF P SUB 97
0.9689698	0.9764283	0.9828730	0.9882974	0.9926959	ZEROES OF P SUB 97
0.9960638	0.9983977	0.9996958	0.0	0.0	ZEROES OF P SUB 97
0.0159463	0.0478226	0.0796504	0.1113971	0.1430305	ZEROES OF P SUB 98
0.1745184	0.2058287	0.2369298	0.2677898	0.2983775	ZEROES OF P SUB 98
0.3286616	0.3586114	0.3881965	0.4173868	0.4461524	ZEROES OF P SUB 98
0.4744643	0.5022935	0.5296119	0.5563915	0.5826052	ZEROES OF P SUB 98
0.6082263	0.6332287	0.6575871	0.6812765	0.7042730	ZEROES OF P SUB 98
0.7265531	0.7480942	0.7688744	0.7888725	0.8080682	ZEROES OF P SUB 98
0.8264420	0.8439751	0.8606498	0.8764490	0.8913568	ZEROES OF P SUB 98
0.9053579	0.9184381	0.9305841	0.9417835	0.9520250	ZEROES OF P SUB 98
0.9612981	0.9695935	0.9769026	0.9832180	0.9885334	ZEROES OF P SUB 98
0.9928433	0.9961433	0.9984301	0.9997020	0.0	ZEROES OF P SUB 98
0.0315682	0.0631048	0.0945786	0.1259581	0.1572121	ZEROES OF P SUB 99
0.1883093	0.2192188	0.2499098	0.2803517	0.3105141	ZEROES OF P SUB 99
0.3403670	0.3698806	0.3990255	0.4277727	0.4560934	ZEROES OF P SUB 99
0.4839595	0.5113432	0.5382171	0.5645546	0.5903292	ZEROES OF P SUB 99
0.6155155	0.6400881	0.6640228	0.6872955	0.7098831	ZEROES OF P SUB 99
0.7317630	0.7529136	0.7733136	0.7929427	0.8117815	ZEROES OF P SUB 99
0.8298110	0.8470133	0.8633714	0.8788688	0.8934901	ZEROES OF P SUB 99
0.9072208	0.9200471	0.9319564	0.9429366	0.9529769	ZEROES OF P SUB 99
0.9620672	0.9701986	0.9773628	0.9835527	0.9887623	ZEROES OF P SUB 99
0.9929862	0.9962203	0.9984615	0.9997079	0.0	ZEROES OF P SUB 99
0.0156290	0.0468717	0.0780686	0.1091892	0.1402031	ZEROES OF P SUB 100
0.1710801	0.2017899	0.2323025	0.2625881	0.2926172	ZEROES OF P SUB 100
0.3223603	0.3517885	0.3808730	0.4095853	0.4378974	ZEROES OF P SUB 100
0.4657816	0.4932108	0.5201580	0.5465970	0.5725019	ZEROES OF P SUB 100
0.5978475	0.6226089	0.6467619	0.6702830	0.6931492	ZEROES OF P SUB 100
0.7153381	0.7368281	0.7575981	0.7776279	0.7968979	ZEROES OF P SUB 100
0.8153892	0.8330839	0.8499645	0.8660147	0.8812187	ZEROES OF P SUB 100
0.8955616	0.9090296	0.9216093	0.9332885	0.9440559	ZEROES OF P SUB 100
0.9539008	0.9628137	0.9707858	0.9778094	0.9838775	ZEROES OF P SUB 100
0.9889844	0.9931249	0.9962951	0.9984920	0.9997137	ZEROES OF P SUB 100

7.2 <u>Input for SITBB</u>: (See page 117.)

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   199        32
   1    10.00      0.17   0.00002   0.0        0.0        TOTAL OZONE 0.250
   2    10.00      0.74   0.00016   0.0        0.0        TOTAL OZONE 0.250
   3     5.00      0.80   0.00290   1.00E+03   0.0        TOTAL OZONE 0.250
   4     5.00      1.53   0.00722   2.00E+03   0.0        TOTAL OZONE 0.250
   5     5.00      3.16   0.01750   5.00E+03   0.0        TOTAL OZONE 0.250
   6     5.00      6.55   0.03840   1.10E+04   0.0        TOTAL OZONE 0.250
   7     5.00     13.75   0.06650   3.40E+04   0.0        TOTAL OZONE 0.250
   8     1.00      4.30   0.01500   2.40E+04   0.0        TOTAL OZONE 0.250
   9     1.00      5.10   0.01460   4.50E+04   0.0        TOTAL OZONE 0.250
  10     1.00      6.00   0.01360   6.80E+04   0.0        TOTAL OZONE 0.250
  11     1.00      7.20   0.01220   1.00E+05   0.0        TOTAL OZONE 0.250
  12     1.00      8.30   0.01120   1.24E+05   0.0        TOTAL OZONE 0.250
  13     1.00      9.60   0.00920   1.24E+05   0.0        TOTAL OZONE 0.250
  14     1.00     11.20   0.00710   1.14E+05   0.0        TOTAL OZONE 0.250
  15     1.00     12.60   0.00510   1.03E+05   0.0        TOTAL OZONE 0.250
  16     1.00     14.50   0.00400   9.40E+04   0.0        TOTAL OZONE 0.250
  17     1.00     17.50   0.00240   8.50E+04   0.0        TOTAL OZONE 0.250
  18     1.00     21.50   0.00120   5.00E+04   1.00E+04   TOTAL OZONE 0.250
  19     1.00     24.50   0.00100   1.50E+04   3.00E+04   TOTAL OZONE 0.250
  20     1.00     27.50   0.00080   1.00E+03   6.00E+04   TOTAL OZONE 0.250
  21     1.00     31.50   0.00070   0.0        1.00E+05   TOTAL OZONE 0.250
  22     1.00     35.50   0.00065   0.0        1.00E+05   TOTAL OZONE 0.250
  23     1.00     40.50   0.00065   0.0        1.00E+05   TOTAL OZONE 0.250
  24     1.00     45.00   0.00080   0.0        1.00E+05   TOTAL OZONE 0.250
  25     1.00     51.00   0.00125   0.0        1.00E+05   TOTAL OZONE 0.250
  26     1.00     61.00   0.00150   0.0        1.00E+05   TOTAL OZONE 0.250
  27     1.00     69.00   0.00190   0.0        3.00E+05   TOTAL OZONE 0.250
  28     1.00     75.00   0.00230   0.0        6.00E+05   TOTAL OZONE 0.250
  29     1.00     87.00   0.00245   0.0        1.00E+06   TOTAL OZONE 0.250
  30     1.00     97.00   0.00265   0.0        3.00E+06   TOTAL OZONE 0.250
  31     1.00    100.00   0.00265   0.0        8.90E+06   TOTAL OZONE 0.250
  32     1.00    111.00   0.00240   0.0        2.55E+07   TOTAL OZONE 0.250
 1.00000   1.00000
  1    0.3125     1.0200     1.6700
 0.31250    1.50000    0.05000   45     2.01482E-09     7.34689E-10  HAZE : H
9.99999E-01  2.31931E+00  3.02192E+00  3.16032E+00  3.08516E+00    1    0.31250
2.35267E+00  2.52777E+00  2.20191E+00  1.84584E+00  1.53183E+00    6    0.31250
1.24008E+00  9.84230E-01  7.80118E-01  5.94399E-01  4.64923E-01   11    0.31250
3.41938E-01  2.64741E-01  1.89282E-01  1.45004E-01  1.01564E-01   16    0.31250
7.68209E-02  5.30808E-02  3.95633E-02  2.71256E-02  1.98909E-02   21    0.31250
1.35834E-02  9.80077E-03  6.67955E-03  4.74663E-03  3.22990E-03   26    0.31250
2.26442E-03  1.53789E-03  1.06572E-03  7.21714E-04  4.95168E-04   31    0.31250
3.33958E-04  2.27068E-04  1.52253E-04  1.02582E-04  6.82274E-05   36    0.31250
4.54755E-05  2.98915E-05  1.96272E-05  1.26615E-05  8.11148E-06   41    0.31250
 0.31250    1.50000    0.05000  125     3.01283E-09     1.71144E-09  HAZE : L
1.00000E+00  2.45213E+00  3.46431E+00  4.05385E+00  4.50899E+00    1    0.31250
4.78294E+00  4.94793E+00  5.02117E+00  4.99381E+00  4.92181E+00    6    0.31250
4.78130E+00  4.61482E+00  4.41865E+00  4.20012E+00  3.98373E+00   11    0.31250
3.74525E+00  3.52819E+00  3.29165E+00  3.08409E+00  2.86257E+00   16    0.31250
2.66988E+00  2.46981E+00  2.29476E+00  2.11822E+00  1.96181E+00   21    0.31250
1.80826E+00  1.67053E+00  1.53819E+00  1.41831E+00  1.30500E+00   26    0.31250
1.20200E+00  1.10524E+00  1.01667E+00  9.34350E-01  8.58904E-01   31    0.31250
7.89051E-01  7.25028E-01  6.65875E-01  6.11691E-01  5.61689E-01   36    0.31250
5.15911E-01  4.73706E-01  4.35079E-01  3.99495E-01  3.66928E-01   41    0.31250
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3.36945E-01	3.09501E-01	2.84254E-01	2.61134E-01	2.39878E-01	46	0.31250
2.20404E-01	2.02510E-01	1.86104E-01	1.71038E-01	1.57218E-01	51	0.31250
1.44528E-01	1.32684E-01	1.22191E-01	1.12377E-01	1.03366E-01	56	0.31250
9.50922E-02	8.74916E-02	8.05145E-02	7.41100E-02	6.82161E-02	61	0.31250
6.27990E-02	5.78208E-02	5.32441E-02	4.90368E-02	4.51676E-02	66	0.31250
4.16095E-02	3.83363E-02	3.53251E-02	3.25543E-02	3.00044E-02	71	0.31250
2.76571E-02	2.54962E-02	2.35064E-02	2.16740E-02	1.99859E-02	76	0.31250
1.84309E-02	1.69981E-02	1.56775E-02	1.44604E-02	1.33382E-02	81	0.31250
1.23038E-02	1.13496E-02	1.04696E-02	9.65778E-03	8.90880E-03	86	0.31250
8.21771E-03	7.57992E-03	6.99124E-03	6.44777E-03	5.94608E-03	91	0.31250
5.48299E-03	5.05519E-03	4.66022E-03	4.29520E-03	3.95801E-03	96	0.31250
3.64652E-03	3.35873E-03	3.09283E-03	2.84713E-03	2.62011E-03	101	0.31250
2.41034E-03	2.21651E-03	2.03739E-03	1.87189E-03	1.71897E-03	106	0.31250
1.57768E-03	1.44717E-03	1.32660E-03	1.21525E-03	1.11241E-03	111	0.31250
1.01747E-03	9.29842E-04	8.48968E-04	7.74362E-04	7.05556E-04	116	0.31250
6.42124E-04	5.83674E-04	5.29835E-04	4.80274E-04	4.34680E-04	121	0.31250

VIII. OUTPUT FROM A TEST RUN

8.1 Output from SITAA: Note: Only a selected portion of the output is reproduced in the following pages (see page 120).

INTEGRAL EXP(-TAU/MU) * P SUB 0 OF MU * DMU FOR TAU EQUAL TO

TAU	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	1.0000E+00	9.4966E-01	9.1311E-01	8.8167E-01	8.5354E-01	8.2783E-01	8.0405E-01	7.8184E-01	7.6096E-01	7.4124E-01
0.100	7.2254E-01	7.0475E-01	6.8778E-01	6.7154E-01	6.5598E-01	6.4104E-01	6.2667E-01	6.1284E-01	5.9951E-01	5.8664E-01
0.200	5.7420E-01	5.6217E-01	5.5054E-01	5.3926E-01	5.2833E-01	5.1773E-01	5.0744E-01	4.9745E-01	4.8774E-01	4.7830E-01
0.300	4.6912E-01	4.6018E-01	4.5148E-01	4.4301E-01	4.3476E-01	4.2671E-01	4.1887E-01	4.1122E-01	4.0376E-01	3.9648E-01
0.400	3.8937E-01	3.8243E-01	3.7565E-01	3.6903E-01	3.6255E-01	3.5623E-01	3.5005E-01	3.4400E-01	3.3809E-01	3.3230E-01
0.500	3.2664E-01	3.2111E-01	3.1569E-01	3.1038E-01	3.0519E-01	3.0010E-01	2.9512E-01	2.9024E-01	2.8546E-01	2.8077E-01
0.600	2.7618E-01	2.7169E-01	2.6728E-01	2.6295E-01	2.5872E-01	2.5456E-01	2.5048E-01	2.4649E-01	2.4257E-01	2.3872E-01
0.700	2.3495E-01	2.3124E-01	2.2761E-01	2.2405E-01	2.2055E-01	2.1711E-01	2.1374E-01	2.1043E-01	2.0718E-01	2.0399E-01
0.800	2.0085E-01	1.9777E-01	1.9475E-01	1.9178E-01	1.8886E-01	1.8600E-01	1.8318E-01	1.8042E-01	1.7770E-01	1.7503E-01
0.900	1.7240E-01	1.6982E-01	1.6729E-01	1.6480E-01	1.6235E-01	1.5994E-01	1.5757E-01	1.5525E-01	1.5296E-01	1.5071E-01
1.000	1.4850E-01	1.4632E-01	1.4418E-01	1.4208E-01	1.4001E-01	1.3797E-01	1.3597E-01	1.3400E-01	1.3206E-01	1.3016E-01
1.100	1.2828E-01	1.2644E-01	1.2462E-01	1.2283E-01	1.2108E-01	1.1935E-01	1.1765E-01	1.1597E-01	1.1432E-01	1.1270E-01
1.200	1.1110E-01	1.0953E-01	1.0799E-01	1.0646E-01	1.0496E-01	1.0349E-01	1.0204E-01	1.0061E-01	9.9197E-02	9.7811E-02
1.300	9.6446E-02	9.5101E-02	9.3778E-02	9.2475E-02	9.1191E-02	8.9927E-02	8.8683E-02	8.7457E-02	8.6250E-02	8.5061E-02
1.400	8.3890E-02	8.2736E-02	8.1600E-02	8.0481E-02	7.9379E-02	7.8293E-02	7.7223E-02	7.6169E-02	7.5131E-02	7.4108E-02
1.500	7.3101E-02	7.2108E-02	7.1130E-02	7.0166E-02	6.9216E-02	6.8281E-02	6.7359E-02	6.6450E-02	6.5555E-02	6.4673E-02
1.600	6.3803E-02	6.2946E-02	6.2102E-02	6.1270E-02	6.0450E-02	5.9641E-02	5.8845E-02	5.8059E-02	5.7285E-02	5.6523E-02
1.700	5.5771E-02	5.5029E-02	5.4299E-02	5.3579E-02	5.2869E-02	5.2169E-02	5.1479E-02	5.0799E-02	5.0128E-02	4.9467E-02
1.800	4.8815E-02	4.8173E-02	4.7539E-02	4.6915E-02	4.6299E-02	4.5691E-02	4.5093E-02	4.4502E-02	4.3920E-02	4.3346E-02
1.900	4.2780E-02	4.2222E-02	4.1672E-02	4.1129E-02	4.0594E-02	4.0066E-02	3.9546E-02	3.9032E-02	3.8526E-02	3.8027E-02
2.000	3.7534E-02	3.7049E-02	3.6570E-02	3.6097E-02	3.5631E-02	3.5172E-02	3.4718E-02	3.4271E-02	3.3830E-02	3.3395E-02
2.100	3.2966E-02	3.2543E-02	3.2126E-02	3.1714E-02	3.1307E-02	3.0907E-02	3.0511E-02	3.0121E-02	2.9737E-02	2.9357E-02
2.200	2.8983E-02	2.8613E-02	2.8249E-02	2.7889E-02	2.7535E-02	2.7185E-02	2.6839E-02	2.6499E-02	2.6162E-02	2.5831E-02
2.300	2.5504E-02	2.5181E-02	2.4862E-02	2.4548E-02	2.4238E-02	2.3932E-02	2.3630E-02	2.3332E-02	2.3038E-02	2.2748E-02
2.400	2.2461E-02	2.2179E-02	2.1900E-02	2.1625E-02	2.1353E-02	2.1085E-02	2.0821E-02	2.0560E-02	2.0303E-02	2.0048E-02
2.500	1.9798E-02	1.9550E-02	1.9306E-02	1.9065E-02	1.8827E-02	1.8592E-02	1.8360E-02	1.8132E-02	1.7906E-02	1.7683E-02
2.600	1.7463E-02	1.7246E-02	1.7032E-02	1.6820E-02	1.6611E-02	1.6405E-02	1.6202E-02	1.6001E-02	1.5803E-02	1.5608E-02
2.700	1.5414E-02	1.5224E-02	1.5036E-02	1.4850E-02	1.4667E-02	1.4486E-02	1.4307E-02	1.4131E-02	1.3957E-02	1.3785E-02
2.800	1.3615E-02	1.3448E-02	1.3282E-02	1.3119E-02	1.2958E-02	1.2799E-02	1.2642E-02	1.2487E-02	1.2334E-02	1.2183E-02
2.900	1.2034E-02	1.1886E-02	1.1741E-02	1.1597E-02	1.1456E-02	1.1316E-02	1.1177E-02	1.1041E-02	1.0906E-02	1.0773E-02
3.000	1.0642E-02	1.0512E-02	1.0384E-02	1.0258E-02	1.0133E-02	1.0010E-02	9.8881E-03	9.7680E-03	9.6493E-03	9.5322E-03
3.100	9.4165E-03	9.3023E-03	9.1895E-03	9.0781E-03	8.9681E-03	8.8596E-03	8.7523E-03	8.6464E-03	8.5419E-03	8.4386E-03
3.200	8.3366E-03	8.2359E-03	8.1365E-03	8.0383E-03	7.9413E-03	7.8456E-03	7.7510E-03	7.6576E-03	7.5654E-03	7.4743E-03
3.300	7.3843E-03	7.2955E-03	7.2078E-03	7.1211E-03	7.0355E-03	6.9510E-03	6.8676E-03	6.7852E-03	6.7038E-03	6.6234E-03
3.400	6.5440E-03	6.4655E-03	6.3881E-03	6.3116E-03	6.2360E-03	6.1614E-03	6.0877E-03	6.0149E-03	5.9430E-03	5.8720E-03
3.500	5.8019E-03	5.7326E-03	5.6642E-03	5.5966E-03	5.5299E-03	5.4639E-03	5.3988E-03	5.3345E-03	5.2710E-03	5.2082E-03
3.600	5.1462E-03	5.0850E-03	5.0245E-03	4.9648E-03	4.9058E-03	4.8475E-03	4.7899E-03	4.7331E-03	4.6769E-03	4.6214E-03
3.700	4.5666E-03	4.5124E-03	4.4589E-03	4.4061E-03	4.3539E-03	4.3024E-03	4.2514E-03	4.2011E-03	4.1514E-03	4.1023E-03
3.800	4.0538E-03	4.0059E-03	3.9586E-03	3.9118E-03	3.8657E-03	3.8200E-03	3.7750E-03	3.7304E-03	3.6864E-03	3.6430E-03
3.900	3.6000E-03	3.5576E-03	3.5157E-03	3.4743E-03	3.4334E-03	3.3930E-03	3.3531E-03	3.3137E-03	3.2747E-03	3.2363E-03
4.000	3.1982E-03	3.1607E-03	3.1236E-03	3.0869E-03	3.0507E-03	3.0149E-03	2.9795E-03	2.9446E-03	2.9101E-03	2.8760E-03
4.100	2.8423E-03	2.8090E-03	2.7761E-03	2.7436E-03	2.7115E-03	2.6798E-03	2.6484E-03	2.6175E-03	2.5869E-03	2.5566E-03
4.200	2.5268E-03	2.4973E-03	2.4681E-03	2.4393E-03	2.4108E-03	2.3827E-03	2.3549E-03	2.3275E-03	2.3003E-03	2.2735E-03
4.300	2.2470E-03	2.2209E-03	2.1950E-03	2.1695E-03	2.1442E-03	2.1193E-03	2.0946E-03	2.0702E-03	2.0462E-03	2.0224E-03
4.400	1.9989E-03	1.9757E-03	1.9527E-03	1.9301E-03	1.9077E-03	1.8855E-03	1.8636E-03	1.8420E-03	1.8207E-03	1.7996E-03
4.500	1.7787E-03	1.7581E-03	1.7377E-03	1.7176E-03	1.6977E-03	1.6780E-03	1.6586E-03	1.6394E-03	1.6205E-03	1.6017E-03
4.600	1.5832E-03	1.5649E-03	1.5468E-03	1.5290E-03	1.5113E-03	1.4938E-03	1.4766E-03	1.4595E-03	1.4427E-03	1.4261E-03
4.700	1.4096E-03	1.3933E-03	1.3773E-03	1.3614E-03	1.3457E-03	1.3302E-03	1.3149E-03	1.2997E-03	1.2848E-03	1.2700E-03
4.800	1.2554E-03	1.2409E-03	1.2267E-03	1.2125E-03	1.1986E-03	1.1848E-03	1.1712E-03	1.1578E-03	1.1445E-03	1.1313E-03
4.900	1.1183E-03	1.1055E-03	1.0928E-03	1.0802E-03	1.0679E-03	1.0556E-03	1.0435E-03	1.0315E-03	1.0197E-03	1.0080E-03
5.000	9.9647E-04									

INTEGRAL EXP(-TAU/MU) * P SUB 1 OF MU * DMU FOR TAU EQUAL TO

TAU	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	5.0000E-01	4.9028E-01	4.8097E-01	4.7200E-01	4.6332E-01	4.5492E-01	4.4676E-01	4.3883E-01	4.3112E-01	4.2361E-01
0.100	4.1629E-01	4.0916E-01	4.0219E-01	3.9540E-01	3.8876E-01	3.8228E-01	3.7594E-01	3.6974E-01	3.6368E-01	3.5775E-01
0.200	3.5195E-01	3.4626E-01	3.4070E-01	3.3525E-01	3.2991E-01	3.2468E-01	3.1956E-01	3.1453E-01	3.0961E-01	3.0478E-01
0.300	3.0004E-01	2.9540E-01	2.9084E-01	2.8637E-01	2.8198E-01	2.7767E-01	2.7344E-01	2.6929E-01	2.6522E-01	2.6122E-01
0.400	2.5729E-01	2.5343E-01	2.4964E-01	2.4591E-01	2.4226E-01	2.3866E-01	2.3513E-01	2.3166E-01	2.2825E-01	2.2490E-01
0.500	2.2160E-01	2.1837E-01	2.1518E-01	2.1205E-01	2.0897E-01	2.0595E-01	2.0297E-01	2.0004E-01	1.9717E-01	1.9434E-01
0.600	1.9155E-01	1.8881E-01	1.8612E-01	1.8347E-01	1.8086E-01	1.7829E-01	1.7577E-01	1.7328E-01	1.7084E-01	1.6843E-01
0.700	1.6606E-01	1.6373E-01	1.6144E-01	1.5918E-01	1.5695E-01	1.5477E-01	1.5261E-01	1.5049E-01	1.4840E-01	1.4635E-01
0.800	1.4432E-01	1.4233E-01	1.4037E-01	1.3844E-01	1.3653E-01	1.3466E-01	1.3281E-01	1.3099E-01	1.2920E-01	1.2744E-01
0.900	1.2570E-01	1.2399E-01	1.2231E-01	1.2065E-01	1.1901E-01	1.1740E-01	1.1581E-01	1.1425E-01	1.1271E-01	1.1119E-01
1.000	1.0969E-01	1.0822E-01	1.0677E-01	1.0533E-01	1.0392E-01	1.0253E-01	1.0116E-01	9.9814E-02	9.8484E-02	9.7173E-02
1.100	9.5881E-02	9.4607E-02	9.3352E-02	9.2115E-02	9.0895E-02	8.9693E-02	8.8508E-02	8.7340E-02	8.6189E-02	8.5054E-02
1.200	8.3935E-02	8.2831E-02	8.1744E-02	8.0672E-02	7.9615E-02	7.8572E-02	7.7545E-02	7.6532E-02	7.5533E-02	7.4548E-02
1.300	7.3576E-02	7.2619E-02	7.1674E-02	7.0743E-02	6.9825E-02	6.8919E-02	6.8026E-02	6.7145E-02	6.6277E-02	6.5420E-02
1.400	6.4575E-02	6.3742E-02	6.2921E-02	6.2110E-02	6.1311E-02	6.0523E-02	5.9745E-02	5.8978E-02	5.8222E-02	5.7476E-02
1.500	5.6739E-02	5.6013E-02	5.5297E-02	5.4591E-02	5.3894E-02	5.3206E-02	5.2528E-02	5.1859E-02	5.1199E-02	5.0548E-02
1.600	4.9906E-02	4.9272E-02	4.8647E-02	4.8030E-02	4.7421E-02	4.6821E-02	4.6228E-02	4.5644E-02	4.5067E-02	4.4498E-02
1.700	4.3937E-02	4.3383E-02	4.2836E-02	4.2297E-02	4.1764E-02	4.1239E-02	4.0721E-02	4.0210E-02	3.9705E-02	3.9207E-02
1.800	3.8716E-02	3.8231E-02	3.7752E-02	3.7280E-02	3.6814E-02	3.6354E-02	3.5900E-02	3.5452E-02	3.5010E-02	3.4574E-02
1.900	3.4143E-02	3.3718E-02	3.3299E-02	3.2885E-02	3.2476E-02	3.2073E-02	3.1675E-02	3.1282E-02	3.0894E-02	3.0511E-02
2.000	3.0133E-02	2.9760E-02	2.9392E-02	2.9029E-02	2.8670E-02	2.8316E-02	2.7967E-02	2.7622E-02	2.7282E-02	2.6945E-02
2.100	2.6614E-02	2.6286E-02	2.5963E-02	2.5644E-02	2.5328E-02	2.5017E-02	2.4710E-02	2.4407E-02	2.4108E-02	2.3812E-02
2.200	2.3521E-02	2.3233E-02	2.2948E-02	2.2668E-02	2.2391E-02	2.2117E-02	2.1847E-02	2.1580E-02	2.1317E-02	2.1057E-02
2.300	2.0800E-02	2.0547E-02	2.0297E-02	2.0050E-02	1.9806E-02	1.9565E-02	1.9327E-02	1.9092E-02	1.8860E-02	1.8631E-02
2.400	1.8405E-02	1.8182E-02	1.7962E-02	1.7744E-02	1.7529E-02	1.7317E-02	1.7108E-02	1.6901E-02	1.6696E-02	1.6495E-02
2.500	1.6295E-02	1.6099E-02	1.5904E-02	1.5713E-02	1.5523E-02	1.5336E-02	1.5151E-02	1.4969E-02	1.4789E-02	1.4611E-02
2.600	1.4435E-02	1.4261E-02	1.4090E-02	1.3921E-02	1.3754E-02	1.3588E-02	1.3425E-02	1.3264E-02	1.3105E-02	1.2948E-02
2.700	1.2793E-02	1.2640E-02	1.2489E-02	1.2339E-02	1.2192E-02	1.2046E-02	1.1902E-02	1.1760E-02	1.1619E-02	1.1481E-02
2.800	1.1344E-02	1.1208E-02	1.1075E-02	1.0943E-02	1.0812E-02	1.0684E-02	1.0556E-02	1.0431E-02	1.0307E-02	1.0184E-02
2.900	1.0063E-02	9.9433E-03	9.8252E-03	9.7085E-03	9.5933E-03	9.4794E-03	9.3669E-03	9.2558E-03	9.1461E-03	9.0377E-03
3.000	8.9306E-03	8.8249E-03	8.7204E-03	8.6172E-03	8.5152E-03	8.4145E-03	8.3150E-03	8.2167E-03	8.1197E-03	8.0238E-03
3.100	7.9290E-03	7.8354E-03	7.7430E-03	7.6516E-03	7.5614E-03	7.4723E-03	7.3842E-03	7.2972E-03	7.2113E-03	7.1264E-03
3.200	7.0425E-03	6.9596E-03	6.8778E-03	6.7969E-03	6.7170E-03	6.6381E-03	6.5601E-03	6.4830E-03	6.4069E-03	6.3317E-03
3.300	6.2574E-03	6.1840E-03	6.1115E-03	6.0399E-03	5.9691E-03	5.8992E-03	5.8301E-03	5.7618E-03	5.6944E-03	5.6277E-03
3.400	5.5619E-03	5.4969E-03	5.4326E-03	5.3691E-03	5.3064E-03	5.2444E-03	5.1831E-03	5.1226E-03	5.0628E-03	5.0037E-03
3.500	4.9454E-03	4.8877E-03	4.8307E-03	4.7744E-03	4.7188E-03	4.6638E-03	4.6095E-03	4.5558E-03	4.5028E-03	4.4504E-03
3.600	4.3986E-03	4.3475E-03	4.2969E-03	4.2470E-03	4.1976E-03	4.1489E-03	4.1007E-03	4.0531E-03	4.0060E-03	3.9595E-03
3.700	3.9136E-03	3.8682E-03	3.8233E-03	3.7790E-03	3.7352E-03	3.6919E-03	3.6492E-03	3.6069E-03	3.5651E-03	3.5239E-03
3.800	3.4831E-03	3.4428E-03	3.4030E-03	3.3636E-03	3.3247E-03	3.2863E-03	3.2483E-03	3.2108E-03	3.1737E-03	3.1371E-03
3.900	3.1009E-03	3.0651E-03	3.0297E-03	2.9948E-03	2.9602E-03	2.9261E-03	2.8924E-03	2.8590E-03	2.8261E-03	2.7935E-03
4.000	2.7614E-03	2.7296E-03	2.6981E-03	2.6671E-03	2.6364E-03	2.6061E-03	2.5761E-03	2.5465E-03	2.5172E-03	2.4883E-03
4.100	2.4597E-03	2.4314E-03	2.4035E-03	2.3759E-03	2.3486E-03	2.3217E-03	2.2950E-03	2.2687E-03	2.2427E-03	2.2170E-03
4.200	2.1916E-03	2.1664E-03	2.1416E-03	2.1171E-03	2.0928E-03	2.0689E-03	2.0452E-03	2.0218E-03	1.9986E-03	1.9758E-03
4.300	1.9531E-03	1.9308E-03	1.9087E-03	1.8869E-03	1.8653E-03	1.8440E-03	1.8230E-03	1.8021E-03	1.7815E-03	1.7612E-03
4.400	1.7411E-03	1.7212E-03	1.7016E-03	1.6822E-03	1.6630E-03	1.6440E-03	1.6253E-03	1.6067E-03	1.5884E-03	1.5703E-03
4.500	1.5524E-03	1.5348E-03	1.5173E-03	1.5000E-03	1.4829E-03	1.4660E-03	1.4494E-03	1.4329E-03	1.4166E-03	1.4005E-03
4.600	1.3845E-03	1.3688E-03	1.3532E-03	1.3379E-03	1.3227E-03	1.3076E-03	1.2928E-03	1.2781E-03	1.2636E-03	1.2492E-03
4.700	1.2351E-03	1.2211E-03	1.2072E-03	1.1935E-03	1.1800E-03	1.1666E-03	1.1534E-03	1.1403E-03	1.1274E-03	1.1146E-03
4.800	1.1020E-03	1.0895E-03	1.0772E-03	1.0650E-03	1.0529E-03	1.0410E-03	1.0292E-03	1.0176E-03	1.0060E-03	9.9467E-04
4.900	9.8342E-04	9.7230E-04	9.6131E-04	9.5045E-04	9.3971E-04	9.2909E-04	9.1859E-04	9.0822E-04	8.9796E-04	8.8782E-04
5.000	8.7780E-04									

INTEGRAL EXP(-TAU/MU) * P SUB 2 OF MU * DMU FOR TAU EQUAL TO

TAU	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	-3.6221E-15	1.7743E-02	2.8737E-02	3.7307E-02	4.4359E-02	5.0324E-02	5.5456E-02	5.9920E-02	6.3833E-02	6.7281E-02
0.100	7.0332E-02	7.3037E-02	7.5441E-02	7.7578E-02	7.9477E-02	8.1164E-02	8.2660E-02	8.3983E-02	8.5150E-02	8.6175E-02
0.200	8.7070E-02	8.7847E-02	8.8515E-02	8.9083E-02	8.9559E-02	8.9950E-02	9.0263E-02	9.0504E-02	9.0678E-02	9.0790E-02
0.300	9.0845E-02	9.0847E-02	9.0800E-02	9.0706E-02	9.0571E-02	9.0396E-02	9.0184E-02	8.9938E-02	8.9660E-02	8.9353E-02
0.400	8.9019E-02	8.8659E-02	8.8276E-02	8.7870E-02	8.7445E-02	8.7000E-02	8.6539E-02	8.6061E-02	8.5568E-02	8.5061E-02
0.500	8.4542E-02	8.4011E-02	8.3470E-02	8.2918E-02	8.2358E-02	8.1789E-02	8.1214E-02	8.0631E-02	8.0042E-02	7.9448E-02
0.600	7.8849E-02	7.8245E-02	7.7638E-02	7.7027E-02	7.6414E-02	7.5798E-02	7.5181E-02	7.4561E-02	7.3941E-02	7.3320E-02
0.700	7.2698E-02	7.2076E-02	7.1453E-02	7.0832E-02	7.0211E-02	6.9590E-02	6.8971E-02	6.8353E-02	6.7737E-02	6.7122E-02
0.800	6.6509E-02	6.5898E-02	6.5290E-02	6.4683E-02	6.4080E-02	6.3478E-02	6.2880E-02	6.2285E-02	6.1692E-02	6.1103E-02
0.900	6.0516E-02	5.9933E-02	5.9354E-02	5.8778E-02	5.8205E-02	5.7636E-02	5.7070E-02	5.6509E-02	5.5951E-02	5.5396E-02
1.000	5.4846E-02	5.4299E-02	5.3757E-02	5.3218E-02	5.2684E-02	5.2153E-02	5.1626E-02	5.1104E-02	5.0585E-02	5.0071E-02
1.100	4.9560E-02	4.9054E-02	4.8552E-02	4.8054E-02	4.7560E-02	4.7071E-02	4.6585E-02	4.6104E-02	4.5626E-02	4.5153E-02
1.200	4.4684E-02	4.4219E-02	4.3759E-02	4.3302E-02	4.2849E-02	4.2401E-02	4.1956E-02	4.1516E-02	4.1079E-02	4.0647E-02
1.300	4.0219E-02	3.9794E-02	3.9374E-02	3.8957E-02	3.8545E-02	3.8136E-02	3.7731E-02	3.7330E-02	3.6933E-02	3.6540E-02
1.400	3.6151E-02	3.5765E-02	3.5383E-02	3.5005E-02	3.4630E-02	3.4260E-02	3.3893E-02	3.3529E-02	3.3169E-02	3.2813E-02
1.500	3.2460E-02	3.2111E-02	3.1765E-02	3.1423E-02	3.1084E-02	3.0749E-02	3.0417E-02	3.0088E-02	2.9763E-02	2.9441E-02
1.600	2.9122E-02	2.8807E-02	2.8494E-02	2.8186E-02	2.7880E-02	2.7577E-02	2.7278E-02	2.6981E-02	2.6688E-02	2.6398E-02
1.700	2.6110E-02	2.5826E-02	2.5545E-02	2.5266E-02	2.4991E-02	2.4718E-02	2.4448E-02	2.4182E-02	2.3918E-02	2.3656E-02
1.800	2.3398E-02	2.3142E-02	2.2889E-02	2.2638E-02	2.2391E-02	2.2145E-02	2.1903E-02	2.1663E-02	2.1426E-02	2.1191E-02
1.900	2.0958E-02	2.0728E-02	2.0501E-02	2.0276E-02	2.0053E-02	1.9833E-02	1.9615E-02	1.9400E-02	1.9187E-02	1.8976E-02
2.000	1.8767E-02	1.8561E-02	1.8357E-02	1.8155E-02	1.7955E-02	1.7757E-02	1.7562E-02	1.7368E-02	1.7177E-02	1.6988E-02
2.100	1.6801E-02	1.6616E-02	1.6433E-02	1.6251E-02	1.6072E-02	1.5895E-02	1.5720E-02	1.5546E-02	1.5375E-02	1.5205E-02
2.200	1.5038E-02	1.4872E-02	1.4707E-02	1.4545E-02	1.4385E-02	1.4226E-02	1.4069E-02	1.3913E-02	1.3760E-02	1.3608E-02
2.300	1.3457E-02	1.3309E-02	1.3162E-02	1.3016E-02	1.2872E-02	1.2730E-02	1.2589E-02	1.2450E-02	1.2313E-02	1.2176E-02
2.400	1.2042E-02	1.1909E-02	1.1777E-02	1.1647E-02	1.1518E-02	1.1391E-02	1.1265E-02	1.1140E-02	1.1017E-02	1.0895E-02
2.500	1.0774E-02	1.0655E-02	1.0537E-02	1.0421E-02	1.0305E-02	1.0191E-02	1.0079E-02	9.9672E-03	9.8569E-03	9.7478E-03
2.600	9.6399E-03	9.5333E-03	9.4278E-03	9.3234E-03	9.2202E-03	9.1182E-03	9.0173E-03	8.9175E-03	8.8188E-03	8.7212E-03
2.700	8.6247E-03	8.5292E-03	8.4348E-03	8.3414E-03	8.2491E-03	8.1578E-03	8.0675E-03	7.9782E-03	7.8899E-03	7.8026E-03
2.800	7.7162E-03	7.6308E-03	7.5464E-03	7.4629E-03	7.3803E-03	7.2986E-03	7.2178E-03	7.1379E-03	7.0589E-03	6.9808E-03
2.900	6.9036E-03	6.8272E-03	6.7516E-03	6.6769E-03	6.6030E-03	6.5299E-03	6.4577E-03	6.3862E-03	6.3156E-03	6.2457E-03
3.000	6.1766E-03	6.1083E-03	6.0407E-03	5.9739E-03	5.9078E-03	5.8424E-03	5.7778E-03	5.7139E-03	5.6507E-03	5.5882E-03
3.100	5.5264E-03	5.4652E-03	5.4048E-03	5.3450E-03	5.2859E-03	5.2275E-03	5.1697E-03	5.1125E-03	5.0560E-03	5.0001E-03
3.200	4.9448E-03	4.8901E-03	4.8361E-03	4.7826E-03	4.7297E-03	4.6775E-03	4.6258E-03	4.5746E-03	4.5241E-03	4.4741E-03
3.300	4.4246E-03	4.3757E-03	4.3274E-03	4.2796E-03	4.2323E-03	4.1855E-03	4.1393E-03	4.0936E-03	4.0484E-03	4.0036E-03
3.400	3.9594E-03	3.9157E-03	3.8724E-03	3.8297E-03	3.7874E-03	3.7456E-03	3.7042E-03	3.6633E-03	3.6229E-03	3.5829E-03
3.500	3.5433E-03	3.5042E-03	3.4655E-03	3.4273E-03	3.3895E-03	3.3521E-03	3.3151E-03	3.2785E-03	3.2423E-03	3.2066E-03
3.600	3.1712E-03	3.1362E-03	3.1016E-03	3.0674E-03	3.0336E-03	3.0001E-03	2.9670E-03	2.9343E-03	2.9020E-03	2.8700E-03
3.700	2.8383E-03	2.8070E-03	2.7761E-03	2.7455E-03	2.7152E-03	2.6853E-03	2.6557E-03	2.6264E-03	2.5975E-03	2.5689E-03
3.800	2.5406E-03	2.5126E-03	2.4849E-03	2.4575E-03	2.4305E-03	2.4037E-03	2.3772E-03	2.3510E-03	2.3252E-03	2.2996E-03
3.900	2.2742E-03	2.2492E-03	2.2244E-03	2.2000E-03	2.1757E-03	2.1518E-03	2.1281E-03	2.1047E-03	2.0815E-03	2.0586E-03
4.000	2.0360E-03	2.0136E-03	1.9914E-03	1.9695E-03	1.9479E-03	1.9264E-03	1.9053E-03	1.8843E-03	1.8636E-03	1.8431E-03
4.100	1.8228E-03	1.8028E-03	1.7830E-03	1.7634E-03	1.7440E-03	1.7248E-03	1.7059E-03	1.6871E-03	1.6686E-03	1.6503E-03
4.200	1.6321E-03	1.6142E-03	1.5965E-03	1.5789E-03	1.5616E-03	1.5444E-03	1.5275E-03	1.5107E-03	1.4941E-03	1.4777E-03
4.300	1.4615E-03	1.4454E-03	1.4296E-03	1.4139E-03	1.3984E-03	1.3830E-03	1.3679E-03	1.3528E-03	1.3380E-03	1.3233E-03
4.400	1.3088E-03	1.2944E-03	1.2802E-03	1.2662E-03	1.2523E-03	1.2386E-03	1.2250E-03	1.2116E-03	1.1983E-03	1.1852E-03
4.500	1.1722E-03	1.1593E-03	1.1466E-03	1.1340E-03	1.1216E-03	1.1093E-03	1.0972E-03	1.0852E-03	1.0733E-03	1.0615E-03
4.600	1.0499E-03	1.0384E-03	1.0270E-03	1.0158E-03	1.0046E-03	9.9364E-04	9.8276E-04	9.7200E-04	9.6136E-04	9.5083E-04
4.700	9.4043E-04	9.3013E-04	9.1995E-04	9.0989E-04	8.9993E-04	8.9008E-04	8.8035E-04	8.7072E-04	8.6119E-04	8.5177E-04
4.800	8.4246E-04	8.3324E-04	8.2413E-04	8.1512E-04	8.0621E-04	7.9739E-04	7.8867E-04	7.8005E-04	7.7153E-04	7.6309E-04
4.900	7.5475E-04	7.4651E-04	7.3835E-04	7.3028E-04	7.2230E-04	7.1441E-04	7.0661E-04	6.9889E-04	6.9125E-04	6.8370E-04
5.000	6.7624E-04									

8.2 Output from SITBB: Note: Only a selected portion of the output is reproduced for the set no. 5 (page 127), and set no. 6 (pages 128, 129, and 130). (See page 124.)

LAYER NUMBER	GEOMETRIC THICKNESS	PRESSURE THICKNESS	OZONE AMOUNT	STRATOSPHERIC DUST CONTENT	TROPOSPHERIC DUST CONTENT
1	10.00	0.17	0.00002	0.0	0.0
2	10.00	0.74	0.00016	0.0	0.0
3	5.00	0.80	0.00290	1.00E+03	0.0
4	5.00	1.53	0.00722	2.00E+03	0.0
5	5.00	3.16	0.01750	5.00E+03	0.0
6	5.00	6.55	0.03840	1.10E+04	0.0
7	5.00	13.75	0.06650	3.40E+04	0.0
8	1.00	4.30	0.01500	2.40E+04	0.0
9	1.00	5.10	0.01460	4.50E+04	0.0
10	1.00	6.00	0.01360	6.80E+04	0.0
11	1.00	7.20	0.01220	1.00E+05	0.0
12	1.00	8.30	0.01120	1.24E+05	0.0
13	1.00	9.60	0.00920	1.24E+05	0.0
14	1.00	11.20	0.00710	1.14E+05	0.0
15	1.00	12.60	0.00510	1.03E+05	0.0
16	1.00	14.50	0.00400	9.40E+04	0.0
17	1.00	17.50	0.00240	8.50E+04	0.0
18	1.00	21.50	0.00120	5.00E+04	1.00E+04
19	1.00	24.50	0.00100	1.50E+04	3.00E+04
20	1.00	27.50	0.00080	1.00E+03	6.00E+04
21	1.00	31.50	0.00070	0.0	1.00E+05
22	1.00	35.50	0.00065	0.0	1.00E+05
23	1.00	40.50	0.00065	0.0	1.00E+05
24	1.00	45.00	0.00080	0.0	1.00E+05
25	1.00	51.00	0.00125	0.0	1.00E+05
26	1.00	61.00	0.00150	0.0	1.00E+05
27	1.00	69.00	0.00190	0.0	3.00E+05
28	1.00	75.00	0.00230	0.0	6.00E+05
29	1.00	87.00	0.00245	0.0	1.00E+06
30	1.00	97.00	0.00265	0.0	3.00E+06
31	1.00	100.00	0.00265	0.0	8.90E+06
32	1.00	111.00	0.00240	0.0	2.55E+07

LEGENDRE COEFFICIENTS REPRESENTING PHASE FUNCTION FOR THE STRATOSPHERIC AEROSOL AT WAVELENGTH OF 0.31250

L	L	L+1	L+2	L+3	L+4	L+5	L+6	L+7	L+8	L+9
0	1.0000E+00	2.3193E+00	3.0219E+00	3.1603E+00	3.0852E+00	2.8527E+00	2.5278E+00	2.2019E+00	1.8458E+00	1.5318E+00
10	1.2401E+00	9.8423E-01	7.8012E-01	5.9440E-01	4.6492E-01	3.4194E-01	2.6474E-01	1.8928E-01	1.4500E-01	1.0156E-01
20	7.6821E-02	5.3081E-02	3.9563E-02	2.7126E-02	1.9891E-02	1.3583E-02	9.8008E-03	6.6795E-03	4.7466E-03	3.2299E-03
30	2.2644E-03	1.5379E-03	1.0657E-03	7.2171E-04	4.9517E-04	3.3396E-04	2.2707E-04	1.5225E-04	1.0258E-04	6.8227E-05
40	4.5476E-05	2.9891E-05	1.9627E-05	1.2661E-05	8.1115E-06	0.0	0.0	0.0	0.0	0.0

LEGENDRE COEFFICIENTS REPRESENTING PHASE FUNCTION FOR THE TROPOSPHERIC AEROSOL AT WAVELENGTH OF 0.31250

L	L	L+1	L+2	L+3	L+4	L+5	L+6	L+7	L+8	L+9
0	1.0000E+00	2.4521E+00	3.4643E+00	4.0539E+00	4.5090E+00	4.7829E+00	4.9479E+00	5.0212E+00	4.9938E+00	4.9218E+00
10	4.7813E+00	4.6148E+00	4.4186E+00	4.2001E+00	3.9837E+00	3.7452E+00	3.5282E+00	3.2916E+00	3.0841E+00	2.8626E+00
20	2.6699E+00	2.4698E+00	2.2948E+00	2.1182E+00	1.9618E+00	1.8083E+00	1.6705E+00	1.5382E+00	1.4183E+00	1.3050E+00
30	1.2020E+00	1.1052E+00	1.0167E+00	9.3435E-01	8.5890E-01	7.8905E-01	7.2503E-01	6.6588E-01	6.1169E-01	5.6169E-01
40	5.1591E-01	4.7371E-01	4.3508E-01	3.9950E-01	3.6693E-01	3.3694E-01	3.0950E-01	2.8425E-01	2.6113E-01	2.3988E-01
50	2.2040E-01	2.0251E-01	1.8610E-01	1.7104E-01	1.5722E-01	1.4453E-01	1.3288E-01	1.2219E-01	1.1238E-01	1.0337E-01
60	9.5392E-02	8.7492E-02	8.0514E-02	7.4110E-02	6.8216E-02	6.2799E-02	5.7821E-02	5.3244E-02	4.9037E-02	4.5168E-02
70	4.1609E-02	3.8336E-02	3.5325E-02	3.2554E-02	3.0004E-02	2.7657E-02	2.5496E-02	2.3506E-02	2.1674E-02	1.9986E-02
80	1.8431E-02	1.6998E-02	1.5678E-02	1.4460E-02	1.3338E-02	1.2304E-02	1.1350E-02	1.0470E-02	9.6578E-03	8.9088E-03
90	8.2177E-03	7.5799E-03	6.9912E-03	6.4478E-03	5.9461E-03	5.4830E-03	5.0552E-03	4.6602E-03	4.2952E-03	3.9580E-03
100	3.6465E-03	3.3587E-03	3.0928E-03	2.8471E-03	2.6201E-03	2.4103E-03	2.2165E-03	2.0374E-03	1.8719E-03	1.7190E-03
110	1.5777E-03	1.4472E-03	1.3266E-03	1.2152E-03	1.1124E-03	1.0175E-03	9.2984E-04	8.4897E-04	7.7436E-04	7.0556E-04
120	6.4212E-04	5.6367E-04	5.2984E-04	4.8027E-04	4.3468E-04	0.0	0.0	0.0	0.0	0.0

VARIOUS NORMAL OPTICAL THICKNESSES OF THE ENTIRE ATMOSPHERIC MODEL : 199

FOR THE INCIDENT RADIATION OF WAVELENGTH : 0.31250

RAYLEIGH SCATTERING	:	1.02000
OZONE ABSORPTION	:	0.41750
STRATOSPHERIC AEROSOL SCATTERING	:	0.00201
STRATOSPHERIC AEROSOL ABSORPTION	:	0.00073
TROPOSPHERIC AEROSOL SCATTERING	:	0.12051
TROPOSPHERIC AEROSOL ABSORPTION	:	0.06846
TOTAL	:	1.62922

ATMOSPHERIC MODEL NUMBER : 199

SURFACE PRESSURE (MB) : 1000.00 TOTAL OZONE AMOUNT (ATM-CM) : 0.250

D U S T D A T A

TYPE OF AEROSOLS	SIZE DISTRIBUTION FUNCTION	PART OF REFRACTIVE INDEX REAL	IMAGINARY	TOTAL AMOUNT
STRATOSPHERIC	HAZE : H	1.500	0.050	1.00E+06
TROPOSPHERIC	HAZE : L	1.500	0.050	4.00E+07

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THIS SET OF COMPUTATIONS IS DONE WITH        60        NUMBER OF TERMS.

CONDITIONING POINT    1       IS AT THE OPTICAL DEPTH   0.0           GIVEN BY THE LEVEL NUMBER    1
CONDITIONING POINT    2       IS AT THE OPTICAL DEPTH   0.14170       GIVEN BY THE LEVEL NUMBER   12
CONDITIONING POINT    3       IS AT THE OPTICAL DEPTH   0.27849       GIVEN BY THE LEVEL NUMBER   20
CONDITIONING POINT    4       IS AT THE OPTICAL DEPTH   0.41822       GIVEN BY THE LEVEL NUMBER   30
CONDITIONING POINT    5       IS AT THE OPTICAL DEPTH   0.54482       GIVEN BY THE LEVEL NUMBER   41
CONDITIONING POINT    6       IS AT THE OPTICAL DEPTH   0.68804       GIVEN BY THE LEVEL NUMBER   50
CONDITIONING POINT    7       IS AT THE OPTICAL DEPTH   0.82091       GIVEN BY THE LEVEL NUMBER   58
CONDITIONING POINT    8       IS AT THE OPTICAL DEPTH   0.96141       GIVEN BY THE LEVEL NUMBER   66
CONDITIONING POINT    9       IS AT THE OPTICAL DEPTH   1.08648       GIVEN BY THE LEVEL NUMBER   73
CONDITIONING POINT   10       IS AT THE OPTICAL DEPTH   1.22345       GIVEN BY THE LEVEL NUMBER   80
CONDITIONING POINT   11       IS AT THE OPTICAL DEPTH   1.37295       GIVEN BY THE LEVEL NUMBER   88
CONDITIONING POINT   12       IS AT THE OPTICAL DEPTH   1.51036       GIVEN BY THE LEVEL NUMBER   95
CONDITIONING POINT   13       IS AT THE OPTICAL DEPTH   1.62920       GIVEN BY THE LEVEL NUMBER  101
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    2
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    3
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    4
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    5
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    6
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    7
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    8
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER    9
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER   10
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER   11
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER   12
THE TOP HALF OF THE F SUB J MATRIX INVERTED AFTER    2      ITERATIONS FOR THE CONDITIONING POINT NUMBER   13
LINEAR SYSTEM SOLVED FOR THETA SUB ZERO =       0.0       AFTER     2     NUMBER OF ITERATIONS.
LINEAR SYSTEM SOLVED FOR THETA SUB ZERO =      45.00      AFTER     2     NUMBER OF ITERATIONS.
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MODEL : 199 WAVELENGTH : 0.3125 THETA SUB ZERO : 0.0

LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX	LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX
1	3.1416E+00	1.5638E-07	3.6659E-01	2.7750E+00	2	3.1409E+00	3.2266E-04	3.6638E-01	2.7749E+00
3	3.1377E+00	1.7289E-03	3.6558E-01	2.7739E+00	4	3.1200E+00	3.1970E-03	3.6746E-01	2.7558E+00
5	3.0778E+00	5.8734E-03	3.7283E-01	2.7108E+00	6	2.9795E+00	1.0916E-02	3.8723E-01	2.6032E+00
7	2.7757E+00	1.9831E-02	4.2313E-01	2.3724E+00	8	2.4492E+00	3.5415E-02	4.9831E-01	1.9863E+00
9	2.3780E+00	4.0289E-02	5.1774E-01	1.9005E+00	10	2.3083E+00	4.6239E-02	5.3755E-01	1.8170E+00
11	2.2423E+00	5.3449E-02	5.5661E-01	1.7392E+00	12	2.1804E+00	6.2477E-02	5.7396E-01	1.6689E+00
13	2.1213E+00	7.2986E-02	5.9023E-01	1.6040E+00	14	2.0679E+00	8.5471E-02	6.0315E-01	1.5502E+00
15	2.0196E+00	1.0042E-01	6.1195E-01	1.5081E+00	16	1.9764E+00	1.1755E-01	6.1634E-01	1.4776E+00
17	1.9339E+00	1.3719E-01	6.1772E-01	1.4534E+00	18	1.8916E+00	1.6112E-01	6.1413E-01	1.4386E+00
19	1.8466E+00	1.9010E-01	6.0555E-01	1.4311E+00	20	1.7977E+00	2.2144E-01	5.9439E-01	1.4247E+00
21	1.7451E+00	2.5488E-01	5.8057E-01	1.4194E+00	22	1.6871E+00	2.9088E-01	5.6356E-01	1.4145E+00
23	1.6246E+00	3.2837E-01	5.4313E-01	1.4099E+00	24	1.5564E+00	3.6730E-01	5.1849E-01	1.4053E+00
25	1.4839E+00	4.0583E-01	4.8993E-01	1.3998E+00	26	1.4051E+00	4.4348E-01	4.5675E-01	1.3918E+00
27	1.3164E+00	4.8144E-01	4.1528E-01	1.3826E+00	28	1.2213E+00	5.1587E-01	3.6686E-01	1.3703E+00
29	1.1239E+00	5.4378E-01	3.1271E-01	1.3549E+00	30	1.0194E+00	5.6547E-01	2.4714E-01	1.3377E+00
31	9.0636E-01	5.7759E-01	1.7198E-01	1.3120E+00	32	7.8131E-01	5.7753E-01	9.3211E-02	1.2656E+00
33	6.1601E-01	5.5908E-01	9.4376E-06	1.1751E+00					

MODEL : 199 WAVELENGTH : 0.3125 THETA SUB ZERO : 45.00

LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX	LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX
1	2.2214E+00	1.6494E-07	2.7050E-01	1.9509E+00	2	2.2208E+00	3.1107E-04	2.7028E-01	1.9508E+00
3	2.2176E+00	1.6666E-03	2.6939E-01	1.9499E+00	4	2.1999E+00	3.0730E-03	2.7057E-01	1.9324E+00
5	2.1580E+00	5.6112E-03	2.7420E-01	1.8894E+00	6	2.0612E+00	1.0300E-02	2.8429E-01	1.7872E+00
7	1.8649E+00	1.8262E-02	3.1005E-01	1.5731E+00	8	1.5626E+00	3.1348E-02	3.6488E-01	1.2291E+00
9	1.4989E+00	3.5319E-02	3.7914E-01	1.1551E+00	10	1.4373E+00	4.0141E-02	3.9365E-01	1.0838E+00
11	1.3796E+00	4.5941E-02	4.0757E-01	1.0179E+00	12	1.3262E+00	5.3176E-02	4.2014E-01	9.5923E-01
13	1.2757E+00	6.1535E-02	4.3186E-01	9.0534E-01	14	1.2306E+00	7.1437E-02	4.4099E-01	8.6109E-01
15	1.1904E+00	8.3283E-02	4.4686E-01	8.2680E-01	16	1.1545E+00	9.6786E-02	4.4933E-01	8.0198E-01
17	1.1197E+00	1.1219E-01	4.4940E-01	7.8253E-01	18	1.0855E+00	1.3088E-01	4.4552E-01	7.7081E-01
19	1.0492E+00	1.5337E-01	4.3763E-01	7.6490E-01	20	1.0102E+00	1.7745E-01	4.2768E-01	7.5998E-01
21	9.6878E-01	2.0278E-01	4.1568E-01	7.5588E-01	22	9.2375E-01	2.2965E-01	4.0122E-01	7.5218E-01
23	8.7586E-01	2.5713E-01	3.8423E-01	7.4876E-01	24	8.2442E-01	2.8510E-01	3.6419E-01	7.4532E-01
25	7.7079E-01	3.1202E-01	3.4143E-01	7.4138E-01	26	7.1368E-01	3.3744E-01	3.1556E-01	7.3556E-01
27	6.5089E-01	3.6195E-01	2.8403E-01	7.2881E-01	28	5.8555E-01	3.8270E-01	2.4817E-01	7.2008E-01
29	5.2067E-01	3.9770E-01	2.0917E-01	7.0919E-01	30	4.5378E-01	4.0690E-01	1.6327E-01	6.9741E-01
31	3.8432E-01	4.0767E-01	1.1214E-01	6.7985E-01	32	3.1161E-01	3.9751E-01	6.0007E-02	6.4911E-01
33	2.2287E-01	3.6843E-01	-3.3591E-05	5.9133E-01					

MODEL : 199 WAVELENGTH : 0.3125 THETA SUB ZERO : 79.60

LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX	LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX
1	5.6712E-01	1.2437E-07	4.2770E-02	5.2435E-01	2	5.6648E-01	2.8093E-04	4.2510E-02	5.2425E-01
3	5.6338E-01	1.4960E-03	4.1391E-02	5.2349E-01	4	5.4625E-01	2.7320E-03	4.0636E-02	5.0835E-01
5	5.0739E-01	4.8539E-03	3.9532E-02	4.7271E-01	6	4.2576E-01	8.3219E-03	3.8033E-02	3.9605E-01
7	2.9063E-01	1.2690E-02	3.6903E-02	2.6641E-01	8	1.4852E-01	1.6372E-02	3.7809E-02	1.2708E-01
9	1.2691E-01	1.7030E-02	3.8329E-02	1.0561E-01	10	1.0840E-01	1.7738E-02	3.8841E-02	8.7297E-02
11	9.3000E-02	1.8535E-02	3.9274E-02	7.2262E-02	12	8.0295E-02	1.9495E-02	3.9515E-02	6.0274E-02
13	6.9552E-02	2.0510E-02	3.9672E-02	5.0390E-02	14	6.0957E-02	2.1682E-02	3.9562E-02	4.3076E-02
15	5.4017E-02	2.3059E-02	3.9106E-02	3.7971E-02	16	4.8407E-02	2.4593E-02	3.8322E-02	3.4678E-02
17	4.3380E-02	2.6252E-02	3.7288E-02	3.2344E-02	18	3.8813E-02	2.8195E-02	3.5815E-02	3.1193E-02
19	3.4354E-02	3.0391E-02	3.3894E-02	3.0851E-02	20	2.9968E-02	3.2484E-02	3.1816E-02	3.0635E-02
21	2.5749E-02	3.4409E-02	2.9634E-02	3.0525E-02	22	2.1642E-02	3.6128E-02	2.7326E-02	3.0444E-02
23	1.7805E-02	3.7532E-02	2.4953E-02	3.0384E-02	24	1.4252E-02	3.8556E-02	2.2494E-02	3.0315E-02
25	1.1117E-02	3.9139E-02	2.0069E-02	3.0187E-02	26	8.3574E-03	3.9211E-02	1.7654E-02	2.9915E-02
27	5.9316E-03	3.8758E-02	1.5101E-02	2.9589E-02	28	3.9943E-03	3.7723E-02	1.2573E-02	2.9144E-02
29	2.5748E-03	3.6172E-02	1.0150E-02	2.8597E-02	30	1.5358E-03	3.4097E-02	7.6122E-03	2.8020E-02
31	8.2206E-04	3.1418E-02	5.0450E-03	2.7195E-02	32	3.7188E-04	2.8049E-02	2.6183E-03	2.5803E-02
33	1.0310E-04	2.3202E-02	-1.3750E-06	2.3307E-02					

MODEL : 199 WAVELENGTH : 0.3125 THETA SUB ZERO : 82.50

LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX	LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX
1	4.1006E-01	1.2831E-07	2.7085E-02	3.8297E-01	2	4.0944E-01	2.7837E-04	2.6822E-02	3.8289E-01
3	4.0642E-01	1.4808E-03	2.5686E-02	3.8222E-01	4	3.8966E-01	2.6952E-03	2.4785E-02	3.6757E-01
5	3.5254E-01	4.7378E-03	2.3352E-02	3.3393E-01	6	2.7804E-01	7.9053E-03	2.1151E-02	2.6479E-01
7	1.6598E-01	1.1373E-02	1.8671E-02	1.5868E-01	8	6.7258E-02	1.3270E-02	1.7279E-02	6.3250E-02
9	5.4491E-02	1.3443E-02	1.7256E-02	5.0679E-02	10	4.4151E-02	1.3613E-02	1.7255E-02	4.0509E-02
11	3.6019E-02	1.3807E-02	1.7242E-02	3.2584E-02	12	2.9661E-02	1.4070E-02	1.7162E-02	2.6569E-02
13	2.4550E-02	1.4341E-02	1.7070E-02	2.1822E-02	14	2.0663E-02	1.4687E-02	1.6883E-02	1.8467E-02
15	1.7666E-02	1.5135E-02	1.6569E-02	1.6231E-02	16	1.5346E-02	1.5653E-02	1.6126E-02	1.4872E-02
17	1.3334E-02	1.6213E-02	1.5589E-02	1.3959E-02	18	1.1565E-02	1.6885E-02	1.4874E-02	1.3575E-02
19	9.8847E-03	1.7635E-02	1.3982E-02	1.3538E-02	20	8.2835E-03	1.8302E-02	1.3047E-02	1.3538E-02
21	6.8014E-03	1.8859E-02	1.2090E-02	1.3570E-02	22	5.4199E-03	1.9285E-02	1.1106E-02	1.3599E-02
23	4.1960E-03	1.9547E-02	1.0122E-02	1.3622E-02	24	3.1303E-03	1.9630E-02	9.1362E-03	1.3624E-02
25	2.2554E-03	1.9514E-02	8.1752E-03	1.3594E-02	26	1.5458E-03	1.9182E-02	7.2308E-03	1.3497E-02
27	9.7980E-04	1.8626E-02	6.2383E-03	1.3368E-02	28	5.7845E-04	1.7858E-02	5.2498E-03	1.3187E-02
29	3.2208E-04	1.6973E-02	4.2883E-03	1.2957E-02	30	1.6143E-04	1.5808E-02	3.2585E-03	1.2711E-02
31	6.9850E-05	1.4476E-02	2.1873E-03	1.2358E-02	32	2.4030E-05	1.2880E-02	1.1485E-03	1.1755E-02
33	4.2218E-06	1.0652E-02	7.1708E-07	1.0655E-02					

MODEL : 199 WAVELENGTH : 0.3125 ISOTROPIC GROUND ILLUMINATION FROM BELOW.

LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX	LAY. NUM.	DIRECT FLUX	DIFFUSE DOWNWARD	DIFFUSE UPWARD	NET FLUX
1	3.0209E-01	2.5664E-06	4.6443E-01	7.6652E-01	2	3.0217E-01	9.6959E-05	4.6448E-01	7.6656E-01
3	3.0257E-01	5.1121E-04	4.6480E-01	7.6685E-01	4	3.0476E-01	9.4437E-04	4.6844E-01	7.7225E-01
5	3.1011E-01	1.7484E-03	4.7756E-01	7.8592E-01	6	3.2326E-01	3.3426E-03	5.0046E-01	8.2038E-01
7	3.5405E-01	6.5305E-03	5.5544E-01	9.0295E-01	8	4.1631E-01	1.3659E-02	6.7040E-01	1.0731E+00
9	4.3263E-01	1.6302E-02	7.0088E-01	1.1172E+00	10	4.4975E-01	1.9698E-02	7.3273E-01	1.1628E+00
11	4.6718E-01	2.3993E-02	7.6462E-01	1.2078E+00	12	4.8468E-01	2.9602E-02	7.9559E-01	1.2507E+00
13	5.0257E-01	3.6457E-02	8.2632E-01	1.2924E+00	14	5.1977E-01	4.5019E-02	8.5401E-01	1.3288E+00
15	5.3627E-01	5.5768E-02	8.7794E-01	1.3584E+00	16	5.5190E-01	6.8576E-02	8.9753E-01	1.3808E+00
17	5.6808E-01	8.3876E-02	9.1509E-01	1.3993E+00	18	5.8506E-01	1.0325E-01	9.2913E-01	1.4109E+00
19	6.0422E-01	1.2775E-01	9.4063E-01	1.4171E+00	20	6.2635E-01	1.5556E-01	9.5177E-01	1.4226E+00
21	6.5185E-01	1.8696E-01	9.6231E-01	1.4273E+00	22	6.8225E-01	2.2264E-01	9.7231E-01	1.4319E+00
23	7.1808E-01	2.6285E-01	9.8123E-01	1.4365E+00	24	7.6130E-01	3.0843E-01	9.8842E-01	1.4413E+00
25	8.1274E-01	3.5878E-01	9.9339E-01	1.4474E+00	26	8.7638E-01	4.1508E-01	9.9572E-01	1.4570E+00
27	9.5971E-01	4.8214E-01	9.9162E-01	1.4692E+00	28	1.0667E+00	5.5741E-01	9.7788E-01	1.4872E+00
29	1.2014E+00	6.3844E-01	9.4969E-01	1.5126E+00	30	1.3849E+00	7.3320E-01	8.9376E-01	1.5454E+00
31	1.6509E+00	8.3673E-01	7.8969E-01	1.6039E+00	32	2.0806E+00	9.3579E-01	5.9043E-01	1.7353E+00
33	3.1416E+00	1.0416E+00	3.7167E-05	2.1000E+00					

SBAR = 0.33155

MODEL NUMBER : 199 WAVELENGTH : 0.3125

0-TH FOURIER COMPONENT OF INTENSITY OF THE RADIATION EMERGENT AT THE TOP (R = 0.0) FOR THETA SUB ZERO =

THETA	AMU	0.0	45.00	60.00	70.00	75.60	79.60	82.50	84.70	86.70	90.00
0.0	1.000	1.378E-01	8.902E-02	5.557E-02	3.064E-02	1.739E-02	9.552E-03	5.376E-03	3.242E-03	2.008E-03	8.674E-04
3.5	0.998	1.377E-01	8.905E-02	5.562E-02	3.068E-02	1.742E-02	9.571E-03	5.389E-03	3.251E-03	2.014E-03	8.700E-04
6.9	0.993	1.374E-01	8.915E-02	5.578E-02	3.081E-02	1.751E-02	9.629E-03	5.426E-03	3.276E-03	2.031E-03	8.779E-04
10.4	0.984	1.371E-01	8.932E-02	5.604E-02	3.102E-02	1.766E-02	9.725E-03	5.489E-03	3.318E-03	2.060E-03	8.912E-04
13.8	0.971	1.366E-01	8.955E-02	5.641E-02	3.132E-02	1.787E-02	9.860E-03	5.577E-03	3.379E-03	2.101E-03	9.100E-04
17.3	0.955	1.361E-01	8.984E-02	5.687E-02	3.170E-02	1.813E-02	1.004E-02	5.692E-03	3.457E-03	2.154E-03	9.348E-04
20.8	0.935	1.354E-01	9.018E-02	5.743E-02	3.216E-02	1.846E-02	1.025E-02	5.836E-03	3.555E-03	2.221E-03	9.659E-04
24.3	0.911	1.345E-01	9.056E-02	5.809E-02	3.271E-02	1.885E-02	1.051E-02	6.008E-03	3.674E-03	2.302E-03	1.004E-03
27.9	0.884	1.335E-01	9.097E-02	5.882E-02	3.334E-02	1.930E-02	1.082E-02	6.213E-03	3.816E-03	2.400E-03	1.050E-03
31.5	0.853	1.323E-01	9.140E-02	5.964E-02	3.404E-02	1.982E-02	1.117E-02	6.451E-03	3.983E-03	2.516E-03	1.104E-03
35.1	0.818	1.309E-01	9.181E-02	6.051E-02	3.482E-02	2.040E-02	1.157E-02	6.727E-03	4.179E-03	2.653E-03	1.169E-03
38.8	0.780	1.292E-01	9.217E-02	6.141E-02	3.566E-02	2.104E-02	1.202E-02	7.046E-03	4.408E-03	2.814E-03	1.246E-03
42.5	0.737	1.272E-01	9.242E-02	6.232E-02	3.656E-02	2.175E-02	1.254E-02	7.414E-03	4.676E-03	3.005E-03	1.338E-03
46.4	0.690	1.247E-01	9.246E-02	6.316E-02	3.748E-02	2.251E-02	1.311E-02	7.839E-03	4.993E-03	3.234E-03	1.449E-03
50.3	0.639	1.217E-01	9.215E-02	6.385E-02	3.839E-02	2.332E-02	1.376E-02	8.335E-03	5.370E-03	3.511E-03	1.586E-03
54.4	0.582	1.177E-01	9.123E-02	6.424E-02	3.923E-02	2.417E-02	1.449E-02	8.919E-03	5.830E-03	3.855E-03	1.758E-03
58.7	0.519	1.123E-01	8.930E-02	6.406E-02	3.988E-02	2.502E-02	1.531E-02	9.625E-03	6.408E-03	4.300E-03	1.986E-03
63.3	0.449	1.044E-01	8.554E-02	6.278E-02	4.009E-02	2.579E-02	1.624E-02	1.051E-02	7.172E-03	4.906E-03	2.305E-03

CONTRIBUTION (MULTIPLIED BY (1-R*SBAR)/R) DUE TO ISOTROPIC ILLUMINATION FROM BELOW.

0.0	1.000	1.400E-01	7.043E-02	3.305E-02	1.355E-02	6.192E-03	2.776E-03	1.269E-03	6.219E-04	3.190E-04	1.181E-04
3.5	0.998	1.398E-01	7.032E-02	3.300E-02	1.353E-02	6.182E-03	2.772E-03	1.267E-03	6.209E-04	3.185E-04	1.179E-04
6.9	0.993	1.391E-01	6.998E-02	3.284E-02	1.346E-02	6.152E-03	2.758E-03	1.261E-03	6.179E-04	3.170E-04	1.173E-04
10.4	0.984	1.379E-01	6.941E-02	3.258E-02	1.336E-02	6.102E-03	2.736E-03	1.251E-03	6.129E-04	3.144E-04	1.163E-04
13.8	0.971	1.364E-01	6.861E-02	3.220E-02	1.320E-02	6.032E-03	2.704E-03	1.236E-03	6.058E-04	3.108E-04	1.150E-04
17.3	0.955	1.343E-01	6.757E-02	3.171E-02	1.300E-02	5.940E-03	2.663E-03	1.218E-03	5.966E-04	3.060E-04	1.133E-04
20.8	0.935	1.317E-01	6.627E-02	3.110E-02	1.275E-02	5.826E-03	2.612E-03	1.194E-03	5.852E-04	3.002E-04	1.111E-04
24.3	0.911	1.286E-01	6.471E-02	3.037E-02	1.245E-02	5.689E-03	2.551E-03	1.166E-03	5.714E-04	2.931E-04	1.085E-04
27.9	0.884	1.249E-01	6.287E-02	2.950E-02	1.210E-02	5.527E-03	2.478E-03	1.133E-03	5.552E-04	2.848E-04	1.054E-04
31.5	0.853	1.207E-01	6.074E-02	2.850E-02	1.169E-02	5.340E-03	2.394E-03	1.095E-03	5.363E-04	2.751E-04	1.018E-04
35.1	0.818	1.158E-01	5.828E-02	2.735E-02	1.121E-02	5.123E-03	2.297E-03	1.050E-03	5.146E-04	2.640E-04	9.769E-05
38.8	0.780	1.102E-01	5.547E-02	2.603E-02	1.067E-02	4.876E-03	2.186E-03	9.996E-04	4.898E-04	2.512E-04	9.297E-05
42.5	0.737	1.039E-01	5.227E-02	2.453E-02	1.006E-02	4.595E-03	2.060E-03	9.420E-04	4.616E-04	2.368E-04	8.762E-05
46.4	0.690	9.668E-02	4.865E-02	2.283E-02	9.360E-03	4.276E-03	1.917E-03	8.767E-04	4.295E-04	2.203E-04	8.154E-05
50.3	0.639	8.851E-02	4.454E-02	2.090E-02	8.569E-03	3.915E-03	1.755E-03	8.026E-04	3.933E-04	2.017E-04	7.465E-05
54.4	0.582	7.925E-02	3.986E-02	1.871E-02	7.672E-03	3.505E-03	1.572E-03	7.186E-04	3.521E-04	1.806E-04	6.684E-05
58.7	0.519	6.870E-02	3.457E-02	1.622E-02	6.651E-03	3.039E-03	1.363E-03	6.230E-04	3.053E-04	1.566E-04	5.795E-05
63.3	0.449	5.662E-02	2.849E-02	1.337E-02	5.481E-03	2.504E-03	1.123E-03	5.134E-04	2.516E-04	1.290E-04	4.775E-05

SBAR = 0.33155